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THE UNIVERSITY OF UTOPIA

ALTHOUGH the discussion on the adaptation of a university to the changing needs of the community, arranged on September 2 by Section L (Education) at the British Association meeting at Oxford, was somewhat circumscribed, the Section was well advised to raise a topic which has such general interest. The shortage of science teachers is only one particularly acute aspect of that general question. The expansion of technical and of technological education, and the supply of scientists and technologists as well as of administrators for industry and elsewhere, are other aspects of the adaptation of a university to the needs of the community. The means we adopt for meeting these changing needs, and the distribution of the nation's resources at the various levels of educational activity, depend in turn on our view of the true functions of a university and the stage at which and the means by which admitted defects are best corrected.

The British Association discussion was unrepresentative. Of its two papers, one, by Mr. J. T. Christie, principal of Jesus College, Oxford, was concerned with Oxford itself, as representing the two ancient universities. The other paper, read by Prof. F. A. Vick, in Prof. W. A. C. Stewart's absence, although concerned with what Sir Richard Livingstone characterized as the most interesting experiment in university education in Britain, could not claim, by itself, to be representative of the modern university. It was limited to a factual account of the University College of North Staffordshire, and an appreciation of the experience of its first four years, particularly with the fundamental idea of the exploratory foundation year. This is, of course, an attempt to broaden the range of academic courses, to meet the plea for more breadth which the Duke of Edinburgh, for example, voiced with such eloquence on his installation as chancellor of the University of Edinburgh. The important argument is, however, how and where the foundation for a broader education should be laid. The Duke of Edinburgh argued soundly that if narrowness begins in school it cannot be cured at the university or anywhere else. It is in school, he suggested, and not at the university, that the budding scientist should be helped, for example, to develop a taste for music and the arts, and the young historian an understanding and reverence for science. Clearly Sir Edward Appleton does not stand alone in deploring as a retrograde step the removal of two such broadening subjects as history and geography as higher subjects from the entrance examination to Scottish universities.

Even if, however, we accept it as a proper responsibility for the university to encourage general study, apart from providing a rich diversity of all the activities which make up civilized life, it should still be remembered that, as the title alone of a broadsheet, "The Keele Experiment" (No. 372; October 18, 1954), issued by Political and Economic Planning reminds us, the University College of North Staffordshire is only an experiment. For all the interest

taken in this experiment in the Dominions and in the United States, as well as in Britain itself, it is far too early to form any opinion on the new type of university education provided at Keele. In ten or so years time, when there will have been more than a thousand graduates, it will be easier to see how the experiment is working. Meanwhile, this experimental basis makes a university college of no more than four hundred students completely unrepresentative of the 30,000 students in other modern English universities and university colleges, excluding London; moreover, there was no contribution to the British Association discussion from the University of London or the universities of Wales and Scotland.

Mr. Christie, however, not only fairly represented the nearly 15,000 students at Oxford and Cambridge, but also raised some significant points. His paper left no doubt that both universities are changing under the impact of social as well as of economic conditions, and that their growing dependence on State aid and the wider range of society from which their students are drawn involve problems and even threats to the performance of their functions. Mr. Christie is satisfied that there is at Oxford still the right balance of arts and sciences to provide a background for that wider informal education which is conducted by discussion and by living together in college. He indicated, however, that the university is increasingly concerned to meet the needs here of those students who come from homes with few books or cultural amenities, and that in these days an ancient university has perhaps a special responsibility for the preservation of the habits of civilized intercourse, and the ideas of knowledge for its own sake and education for leisure.

Such ideas are liable to come under pressure both from the demands of the State and from those of the individual who looks upon a university as being purely a means of training for a career. A university, Mr. Christie agreed, in a sense is always vocational; but once we admit that its essential task is to train men and women for the community and in the numbers the community requires for particular purposes, we are exposed to a danger of directed education which threatens the whole idea of the pursuit of knowledge for its own sake. Mr. Christie firmly maintained that something more than the vocational idea is an essential element in the university ideal; but although he indicated clearly enough the danger that the social climate may debase the idea of a university, he did not in this paper attempt to formulate any clear conception of the function and purpose of a university.

A valuable contribution to that end is to be found in Dr. R. M. Hutchins's "The University of Utopia"*, and in the Sir George Watson Lectures on "The Idea of an American University" which he has since delivered in Britain. Although Dr. Hutchins's criticism is directed at the university as it exists in the United States, much that he writes about the dangers of specialization, of State control and of social and political conformity has its bearing on problems confronting universities in Britain to-day. The conception of the university and its functions in the world to-day which he embodies in the description of the ideal university of Utopia is no less stimulating and provocative in the British context than in that of the United States. Dr. Hutchins asks the right questions, and although we may not always in Britain give the same answers as are given in the United States, they are questions to which answers must be found before we can wisely decide how far the expansion of university or technological education should proceed, the right balance of studies in the universities, the distribution of resources between university, technological and technical education, the function of the universities in adult education and whether the attempt to secure greater breadth should be pursued in the schools or afterwards.

What stands out most clearly from the discussion at Oxford, and also in the pictures which Dr. Hutchins gives both of the American university and of the University of Utopia, is the dependence of the university on the character of the society it serves. The greatest weaknesses of the American university stem, in Dr. Hutchins's view, from weaknesses in American society. Mr. Christie similarly pointed to weaknesses in the ancient universities of Britain which arise fundamentally from social conditions in the homes from which their students are drawn. It is not primarily a matter of financial dependence, though that can also play a part—and on it Dr. Hutchins makes some caustic comments. The real case for university autonomy lies, in his view, on the proposition that societies require centres of independent thought and criticism if they are to progress or even to survive.

The conception of a university as a centre of independent thought is, of course, not new; nor is it inconsistent with the conception of the university as a place of vocational training, at least in so far as sovereign place is given to the educational rather than to the professional end. The conception of the university as a centre of independent thought, dedicated to the pursuit of truth by untrammelled thinking, by following the argument wherever it may lead, and meeting the critical encounter of other judgments, is implicit in the view of the functions of a university as expressed by the University Grants Committee nearly twenty years ago. Unless the universities are so dedicated and independent, they cannot stimulate and train their students "at least to think, and to think strenuously about the great issues of right and wrong, of liberty and government, on which, both for the individual and for the community, a balanced judgment is essential to a rational life".

Discussions on industry and the universities in recent years have made it unmistakable that such qualities of independent thinking are among those which industry looks for in recruiting university graduates, and the need for them in the Departments of State from Ministerial rank downwards has been forcibly demonstrated of late. The question of the

* The University of Utopia. By Robert M. Hutchins. (Charles R. Walgreen Foundation Lectures.) Pp. ix+103. (Chicago: Univ. of Chicago Press; London: Camb. Univ. Press, 1953.) 19s. net.

true purpose of a university bears closely both on the extent and the character of the vocational or professional education which a university should give. Dr. Hutchins, in depicting the University of Utopia, seems to over-stress one aspect; but it should be remembered that he puts the right question first and also that in his Utopia much education or professional training of university status, in the sense in which the word is commonly used, is carried out in other institutions.

If vocational education deflects the university from its primary function as a centre of independent thought, the imaginative pursuit of learning and the quality of its vocational education will soon suffer. The University of Utopia rests on the assumption that there should be somewhere in the State an organization the purpose of which is to produce men who can think most profoundly about the most important intellectual issues; and Dr. Hutchins, pointing out that this implies that unpopular opinions are likely to be heard in the university from time to time, insists that such a university can only function if its nature and purpose are clearly understood by the community. No one who has followed the post-war discussions on university development or the expansion of higher technological education in Britain can fail to appreciate the soundness of this argument.

Dr. Hutchins goes on to suggest that the first step towards clarifying the popular conception of the purpose and functions of a university is to exclude from the university those activities which are not proper to it, which prevent understanding of the function of the universities, and which create confusion in regard to it. There may be little danger in Great Britain of eccentricities in regard to degree subjects, of which Dr. Hutchins gives fresh examples; but some of the proposals in regard to technological education go far enough in that direction to prevent any self-righteousness. What is important to remember is that, as Mr. N. G. Fisher pointed out at a recent conference of the British Association for Commercial and Industrial Education, the universities are already subjected to pressures from students and the parents of students towards vocational education, or even training, which could easily divert them from their true function. Unless that task of educating public opinion as to the true function of the university is undertaken vigorously and continuously, there is real danger, not so much that insufficient public funds will be forthcoming for the universities, as that the universities will find their teaching so circumscribed by vocational demands that it is conceived solely in terms of qualification for a career.

Fortunately, in Great Britain the universities are still in a key position to influence the social pressures that shape them, and Dr. Hutchins's book is primarily of value as a reminder of the urgency and importance of that responsibility. The task is indeed being undertaken. Sir Hector Hetherington's Essex Hall Lecture last year on "The Social Function of the University", like the reports of the University Grants Committee, are important contributions to that end, and it is worth noting that Sir Hector essentially endorses Dr. Hutchins's criteria as to the fitness of a subject for university study, or indeed for study at any level in an educational system: it must have intellectual content in its own right.

The point is worth emphasizing again, because it bears closely on the expansion of technological education also and on the balance between that and technical education. Clear ideas as to the proper content of university and technological education are essential if standards are to be maintained and our limited resources of teachers of science and technology deployed to provide for the output of scientists and technologists which the interests of Britain manifestly demand. The recent conferences on industry and the universities arranged by the Federation of British Industries have fully endorsed the view set forth in the last quinquennial report from the University Grants Committee, namely, that a university has not fully discharged its obligations unless its teaching is so designed as to ensure for all of its students who use their opportunities the chance to become, in Mill's words, "capable and cultivated human beings". Nevertheless, much more could be done by both parties to those conferences, and probably also by the Parliamentary and Scientific Committee, to put such ideas before Parliament and the public in general.

MICHAEL SERVETUS, 1511–53

Michael Servetus

Humanist and Martyr. By John F. Fulton. (With a bibliography of his works and census of known copies, by Madeline E. Stanton.) Pp. 98+9 plates. (New York: Herbert Reichner, 1953.) 8.50 dollars.

Michael Servetus

A Translation of his Geographical, Medical and Astrological Writings, with Introductions and Notes. By Charles Donald O'Malley. (Memoirs of the American Philosophical Society, Vol. 34.) Pp. 208+5 plates. (Philadelphia: American Philosophical Society, 1953.) 3 dollars.

JUST over four hundred years ago, Michael Servetus, condemned by Calvin, was burned at the stake in Geneva because he had dared to regard the historical interpretation of Jesus as infinitely superior to the complex subtleties of the Trinity. But this original definition of the Unitarian belief is not the chief reason for the high place of Servetus in history. He is remembered to-day mainly as the discoverer of the pulmonary circulation. His anatomical knowledge was sound, and he not only discovered that the blood circulates through the lungs in passing from the right to the left side of the heart, but also he came very near to the anticipation of Harvey's discovery made in the following century, when he explained that "vital spirit is then transferred from the left ventricle of the heart into the arteries of the whole body". Those remarkable statements attracted little notice at the time, because they were buried in the pages of the famous theological work, "Christianismi Restitutio", of which only three copies escaped destruction, and which, as Dr. C. D. O'Malley states,

is the book which helped to bring about its author's death but has also helped to keep his name alive.

This mixture of theology and physiology in a single work may appear strange to us in our own time of extreme specialism. We must recall the fact that the medieval mind was at least versatile, and that Servetus was more interested in the blood-stream as a vehicle for the soul or *spiritus*, rather than as a physiological phenomenon. The fact that an Arabic writer of the thirteenth century, Ibn an-Nafis, whose manuscript was discovered only in 1924, had grasped the idea of the lesser circulation, does not detract from the achievement of Servetus, who was probably unaware of this work. The question of priority is further complicated by the accounts of the pulmonary circulation, by another Spaniard, Valverde, in 1556, and by a successor of Vesalius at Padua, Realdo Colombo, in his "De re anatomica", 1559. Those descriptions may well have been based upon the work of Servetus. Remembering his fate, the writers would hesitate to acknowledge the source of their information. At all events, the discovery remained obscure for long, and Harvey, seventy-five years later, appears to have had no knowledge of Servetus.

All these questions are concisely discussed by Prof. J. F. Fulton in his admirable biography of Servetus. After due reference to the investigations of Galen and of Vesalius, as a background, Prof. Fulton discusses the career of Michael Servetus, on the basis of the comparatively slender evidence available. Studying at the universities of Saragossa and Toulouse, he led a wandering life, and we find him at Bologna and Basle, at Lyons and Paris, and lastly, to his undoing, at Geneva. His first two tracts on the errors of the Trinity, "De Trinitatis Erroribus" (1532) and "Dialogorum de Trinitate" (1533), shocked Catholic and reformer alike; so much so that for the next twenty-five years Servetus assumed the name Michael Villanovanus, after the town of Villanueva in Spain where he had spent his early years.

In Lyons, Servetus translated Ptolemy's "Geography", which had been a standard work since the second century, and added original material of his own. His estimate of the Scots is worth quoting: "They are brave in war, very enduring of hunger and lack of sleep, of pleasing manners, but very lacking in sophistication. They rejoice in falsehood, nor do they cultivate peace as the English". Dr. O'Malley has given us excellent translations of this and other works of Servetus. Among them is "In Leonardum Fuchsium Apologia" (1536), in which Servetus champions Symphorien Champier of Lyons against the equally eminent physician Leonard Fuchs of Tubingen: their quarrel relating to the differing views of the Greeks and the Arabists, whether the new disease of syphilis was the *lichen* of Greek times, and sundry other matters.

Servetus's work on the syrups (a generic term for many of the remedies of his time), "Syruporum Universa Ratio", dated 1537, accounts for more than half the pages of Dr. O'Malley's book. It deals extensively with Galen's views on digestion, or concoction, as he called it, and on the routine use of purgatives as an aid to health—a procedure followed for centuries and not altogether extinct to-day. The Discourse in Favour of Astrology, "Disceptatio pro Astrologia" (1538), shows that Servetus retained the medieval outlook. His translation of the Bible, issued in 1542, probably led Servetus to restate more strongly than ever his heretical views regarding the Trinity, in his "Christianismi Restitutio" of 1553, which led so swiftly to his death as a martyr.

The original editions of the works of Servetus are extremely rare, and the preparation of translations, and of a bibliography, must surely have been very hard tasks. Those tasks have been well performed, and Miss Stanton deserves special praise for a bibliography which presented such unusual problems. These two books, which have been reviewed together, do not conflict in any sense, but each is the complement of the other. Together, they form a worthy memorial to a gallant and tragic spirit who deserves to be remembered four hundred years after his untimely death.

Douglas Guthrie

THE RIGHT TO DISSENT

Freedom, Loyalty, Dissent

By Prof. Henry Steele Commager. Pp. x + 99. (London: Oxford University Press, 1954.) 8*s*. 6*d*. net.

LIKE Prof. A. Macbeath's plea for heretics at the British Association meeting in Belfast, the five essays collected in this volume develop the pragmatic argument that the right to dissent, even to be wrong, is an imperative necessity for a society in which science or any other creative activity is to flourish. The several themes—the necessity of freedom and of experimentation, free enterprise in ideas, guilt by association, who is loyal to America?—are linked by this argument, that to preserve and encourage the exercise of freedom of inquiry, investigation, dissent and association, whether in education, science, literature or politics, is not an abstraction or luxury but a first condition of the survival of a democratic society as it is understood in Great Britain or the United States.

Prof. H. S. Commager's essays are addressed to an American audience, but quite apart from the evidence they afford that there are those in the United States itself who have a national audience and are not afraid to attack McCarthyism, his refreshing defence of intellectual freedom will appeal to all scientists who welcomed Prof. Macbeath's forthright words. In the accents of Mill rather than of Burke, he argues for the encouragement of the experimental attitude in science, because "if we create a climate of opinion in which scientists fear to be bold and original or if we require that they work only on projects that appear to be of immediate importance to us, we shall end up with scientists and scientific knowledge inadequate to the tasks that we impose upon them". Similarly, he argues that without freedom to experiment in politics, the political system will prove inadequate to the demands now made upon it. Without freedom for the scientist, the scholar, the critic, without the open mind in politics, in economics, in international relations, even in the realm of morals we forfeit alike security and the ability to adapt ourselves to new demands or new situations.

Prof. Commager, no more than Prof. Macbeath, is not advocating license. He recognizes that there must be limits on liberty, as there are limits on authority. Here again, the appeal is to the practical, not to the constitutional or to natural rights. To draw the line between the exercise of freedom and the limitations on freedom is one of the most delicate tasks of statesmanship and philosophy, and the governing factor he suggests is that no society can

afford the cumulative costs of the intimidation of thoughtful and critical men and women. Security and progress are most likely to be achieved by a government which scrupulously protects and encourages complete freedom of thought, expression, communication, investigation and criticism. "A society that attempts to put education and science and scholarship in strait jackets will find that in strait jackets there can be no movement and that the result will be intellectual atrophy."

But Prof. Commager does not merely attack. When he touches, for example, on the questions of loyalty and the right of association, he raises issues that run far wider than the activities of McCarthy and which call for examination in a British context. The divorce or gap between membership and responsibility is already embarrassing scientific societies in Britain, and the implications of Prof. Commager's comment here merit examination. What he writes further about the way in which a blow at the principle and practice of voluntary association endangers the working machinery of democracy is supported by the whole argument of such a book as C. D. McIver's "The Ramparts We Defend", or the late Lord Lindsay of Birker's writings on democracy. Once the notion that joining an organization may be dangerous is firmly established, all organizations or institutions will be affected, whether of science, the professions, education, the arts or government itself, and a fatal blow may well be dealt to the functioning of those communal groups in which, in the complexities of to-day, individual men and women increasingly find opportunity for self-expression and for influencing events. Gratitude for a lucid restatement of the case for freedom of thought and a courageous attack on illiberalism should not be allowed to lead to the challenge of this book being ignored, or prevent an examination of exactly why the pragmatic tradition proved too weak to inhibit the growth of McCarthyism. Why this retreat from reason?

R. BRIGHTMAN

DETERMINATION OF CRYSTAL STRUCTURES

The Determination of Crystal Structures

By Dr. H. Lipson and Dr. W. Cochran. (The Crystalline State—Vol. 3.) Pp. ix + 345 + 9 plates. (London: G. Bell and Sons, Ltd., 1953.) 50*s*. net.

SOME crystals seem most reluctant to give up their secrets. Though they are easily persuaded to yield more than enough data for their structures to be found, yet with a perversity inherent in their very nature, they scramble it first. The problem thus presented to the X-ray crystallographer resembles a jig-saw puzzle of several hundred pieces each bearing the same pattern on both its sides, and he must decide where each piece belongs in the picture and which way up it should go—often indeed without any clear idea of what the picture will prove to be. This ambiguity, which conceals such valuable prizes, has called forth great ingenuity, especially during the past few years. The attack has been systematized, and this book is a manual of both strategy and tactics, the first, in fact, to be devoted so fully and exclusively to that end.

The authors presuppose that a set of intensities has been measured on some arbitrary scale, and address themselves to the interpretation, or the finding of a structure which not only makes chemical sense, but is also capable of refinement. This occupies four chapters. The refinement and the precision ultimately achieved are discussed in another chapter, while the first four are devoted to a detailed discussion of all the principles and computational routines which comprise the main tools of the structure analyst.

The volume lacks nothing of the high standards of scholarship and presentation that distinguished its predecessors, but its compilation has presented the authors with problems peculiar to this volume. Like painters busy on the portrait of an active child, they found their subject just would not sit still. Of the 309 references, 143 relate to the years 1948 and onward (three of them in 1953), which are the years in which the book was prepared. This does not imply a neglect of earlier publications, but is a fair indication of the spate of work with which the authors had to contend. One would have been satisfied if they had only harvested this prolific crop. They have, however, done much more. The crop has been threshed and assessed, and at every turn valuable comments are given from their own experience on the best ways of handling each different method: these are the tactics which so rarely find their way into the original literature.

Both the authors are well known to crystallographers as pioneers who have contributed substantially to this subject, and as writers with a clear and easy style. Their practical outlook has not prevented them from including results which, although of no practical utility, have thrown valuable light on the subject. They have effected valuable economies by referring freely to Vols. 1 and 2 of the series and to the "International Tables". In only one place (in the early part of Chapter 2) do they seem a little undecided about the level of experience expected from the reader, for though on one hand the symbols (graphic and Hermann–Mauguin) for screws and glides are introduced without explanation, yet it was apparently deemed necessary to deduce *ab initio* the systematic absences they produce. Very great care has obviously been taken in the proof-reading, for very few misprints have been found and, of these, only one, a tangle of signs in the last equation on p. 80 and the first on p. 81, involve more than a momentary interruption of the reading.

The publishers, too, share in the credit for this book in two ways especially. First, it was decided to make the book comprehensive up to the end of 1952, but the rapid and continued development of the subject could have made the book largely out of date at the time of its appearance had the publishers not co-operated so well. Secondly, the authors use some innovations in the numbering of figures and equations and in their combined author-index and bibliography. These are, as the authors hoped, a great help to all who will wish frequently to consult the book, but it is evident that it involved both the authors and the publishers in considerable extra work. They must be congratulated that the experiment was made and was not allowed to delay the appearance of the book.

The volume is freely illustrated and will stand up to all the hard wear it is sure to get. Its price is reasonable if judged by modern standards of size and quality, but is very reasonable if judged by its usefulness and the wealth of material that has been packed into it. It is certain that this book will

stimulate yet more work, so that it will require considerable expansion in its second edition. It is at present small enough to permit of such expansion, and the foundation already laid should be ample to carry it. Anyway, by the time the second edition appears, these copies will be due for honourable retirement; they are not likely to get much peace until then.

D. Rogers

THE SYNCHRONOUS INDUCTION MOTOR

The Synchronous Induction Motor

By J. Griffin. Pp. 136. (London: Macdonald and Co. (Publishers), Ltd., 1954.) 18*s*. net.

ROTATING electromagnetic machines form a family of machines in which a field-producing element and a current-carrying element react in such a way as either to convert electrical into mechanical energy or vice versa. The different methods used to activate the elements give rise to the various types of machines and include the use of direct or of alternating current and, in the latter case, of supply by direct connexion or by induction. Most types maintain the same methods during running as during starting, and their behaviour under both conditions of operation can be understood from consideration of the basic characteristics of their individual types. But the synchronous induction motor embodies the characteristics of two fundamentally different types: one, the induction motor, actuates both elements from a single source; the other, the synchronous motor, uses two different sources to energize the elements. One difficulty presented to the student of this machine is in understanding how the transition from induction motor to synchronous motor occurs, and how it will affect the machine in its ability to pull into synchronism; and another is in appreciating the effect of direct current flowing in a polyphase winding and producing a magnetic field.

The author of this book treats these problems in a practical manner, and his review is materially helped by the co-operation of manufacturers, who have provided the material for the many plates with which the book is illustrated. Mr. L. H. A. Carr, in a foreword, points out the value of a book which explains to utilization engineers the properties of a machine permitting power-factor control and to teachers the theory of the cylindrical rotor type of synchronous machine.

In the introduction the author pays tribute to the Swedish inventor Danielson, who brought out the motor in 1900, and gives in an appendix a translation of an article in *Elektrotechnische Zeitschrift* (December 26, 1901) by Danielson. A chapter is given to methods of starting, and some important points are made such as the necessity on the grounds of temperature rise to limit horse-power output demands when over-exciting the machine for power-factor correction. There are useful chapters on synchronous motor theory and on the economics of power-factor correction, and the effect of first cost is well discussed. Overload capacity, automatic control and electrodynamic braking are adequately and simply described. The merits of making the rotor carry the primary winding are well brought out, and general limits of the method as to voltage and output are stated.

Secondary windings are described generally and include double three-phase star, open delta, unsymmetrical three-phase star, two-phase with single-phase excited; and the general theory concludes with a comprehensive treatment of the problem of the exciting current and its calculation. A brief chapter on the salient-pole synchronous induction motor is interpolated, presumably for purposes of comparison of performance, and the book concludes with details and examples of general construction. There are a useful bibliography and a good index.

H. M. Clarke

A MODERN VIEW OF INORGANIC CHEMISTRY

Comprehensive Inorganic Chemistry

Edited by Prof. M. Cannon Sneed, Prof. J. Lewis Maynard, and Prof. Robert C. Brasted. Vol. 1: Principles of Atomic and Molecular Structure. By W. N. Lipscomb. Theoretical and Applied Nuclear Chemistry. By P. R. O'Connor. The Actinide Series. By G. T. Seaborg. Pp. xi+232. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1953.) 35*s*. net.

THERE can be many plans for the writing of books. In this case different authors have contributed separate sections, each of which is, in its own way, complete within itself and relatively independent of the others. In such circumstances, one might ask whether the choice of articles is the best and whether any given topic has been developed in the most suitable manner.

The introductory section to the first volume of this series, by William N. Lipscomb, deals with principles of atomic and molecular structure. Discussion is restricted to extra-nuclear properties such as electronic structure, chemical bonds and structures of molecules and crystals. The material is very well presented in a space of eighty pages, an impression of completeness having been achieved by strict adherence to the main theme. The second chapter, on theoretical and applied nuclear chemistry, by P. R. O'Connor, also eighty pages in length, includes a useful account of elementary particles, nuclear structure and radioactivity, followed by a discussion of methods of radioisotope production and applications to chemical problems. The last chapter, on the actinide series, has been written by Prof. G. T. Seaborg. It is, of course, authoritative, and extremely well presented, although perhaps written with rather more bias towards the radiochemical point of view than is necessary in a volume on inorganic chemistry.

This criticism is one which might be levelled at the volume as a whole. The development of atomic energy has undoubtedly led to a great development in radiochemistry, and it is a good thing that this aspect of inorganic chemistry should be well to the fore in a modern treatise. If it seems to have been overdone in this instance, it is probably because the volume has the character of a collection of independent review articles rather than that of a really cohesive treatise. On the other hand, it must not be denied that the system has its merits, particularly when the standard of the individual articles is as good as in the present instance. The book should, therefore, be well received by students and research workers alike.

R. Spence

Infrared Absorption Spectra of Steroids

An Atlas. By Konrad Dobriner, E. R. Katzenellenbogen and R. Norman Jones. Pp. xlv+299. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1953.) 11.50 dollars.

USUALLY infra-red spectra are duplicated or printed separately as in the American Petroleum Institute spectra of hydrocarbons, but occasional attempts have been made to provide collected spectra in book form. Nothing comparable with the present atlas in quality of spectra or wide range of comparatively inaccessible compounds has, however, previously appeared. At first sight, the atlas seems highly priced, but since 306 spectra are presented the cost only works out to about 3*d*. each, which compares favourably with, say, American Petroleum Institute spectra. It is obviously a great convenience to have spectra in book form, neatly classified, and it is probable that in years to come every department of organic chemistry will possess rows of volumes similar to this.

Each spectrum in the atlas has been obtained under the supervision of the authors with 1–5 mgm. of material dissolved in carbon disulphide, carbon tetrachloride or chloroform. By using a double-beam instrument with a variable-length cell in the comparison beam, the solvent absorption has been practically eliminated. The spectral regions covered are 1,800–1,580, 1,480–1,300, 1,400–650 and (in twelve cases) 3,700–2,800 cm.$^{-1}$. Even with steroids differing only in some minor point of structure, the spectra are distinct although the spectral differences may be quite small.

This work was started as an aid to cancer research by the late Dr. K. Dobriner. It is a matter of great regret that the death of this investigator has removed a distinguished pioneer from an important field, but this well-laid foundation will certainly be used to great advantage by others. A. E. MARTIN

Time Counts

The Story of the Calendar. By Harold Watkins. Pp. xi+274. (London: Neville Spearman, Ltd., 1954.) 15*s*. net.

THE first portion of this book gives a brief history of the calendar up to the time of the introduction of the Gregorian Calendar into Great Britain in 1752. If there is a second edition, the first chapter, which is based on the unacceptable theories of Hoerbiger and Bellamy, should be omitted.

The main part of the book is concerned with the various proposals that have been made for the reform of the Gregorian Calendar and, in particular, with the advantages of the scheme advocated by the World Calendar Association. A proposal in favour of the adoption of the World Calendar has recently been brought before the Economic and Social Council of the United Nations Organization by the Government of India, which is concerned with rectifying the complicated calendar situation in India, where many different calendars are in use; India would like, at the same time, to remove the illogicalities and inconveniences of the present calendar.

The Economic and Social Council at its meeting in Geneva at the end of July decided, by a unanimous vote, to refer the question of the reform of the calendar for study by the governments of the world, with the view of its discussion at the nineteenth session of the Council next year.

The fixing of the date of Easter is a separate question. The inconveniences of the date of Easter wandering over a period of thirty-five days are widely felt, and the adoption of the World Calendar would greatly facilitate the fixing of the date of Easter. H. S. J.

Lower Tertiary Foraminifera of the Qatar Peninsula

By Alan Hilder Smout. Pp. ix+96+15 plates. (London: British Museum (Natural History).) 45*s*.

THE title of this monograph obscures the fact that it is essentially a study of the Rotaliidea, almost half the contents being devoted to an account of the structure and evolution of the group, the remainder to systematics. Dr. A. H. Smout demonstrates that the rotaliid test is formed by "instars" of successive laminæ, each of which totally encloses the whole of the previously formed test, so that in *Nummulites*, for example, the test is constructed from a series of "chinese-box laminæ" and not, as previously thought, from a spiral chevron of shell material.

Evidence from physiology and fossil morphology, influenced by D'Arcy Thompson's "Growth and Form", is synthesized into a persuasive morphogenical argument. Conviction that direct adaptations are possible as a result of physical difficulties imposed on the sarcode by increase in size of the test leads to a limited Neo-Lamarckian interpretation, the author, however, being prepared to allow normal genetical factors to fix and translate the acquired character into the earlier stages of succeeding ontogenies. The systematics are concerned with a revised classification of the Rotaliidea; the erection of a new superfamily, the Discorbidea; and a description of rotaliids and a few associated forms from borings in north-east Arabia, including three new genera, *Dictyokathina*, *Kathina* and *Daviesina*, seventeen new species, and two new varieties.

The monograph, which is beautifully printed and illustrated, deserves to be much more widely read than might be expected from its generalized title, since the views expressed are fundamental to adequate appreciation of the structure and morphological evolution of the larger foraminifera.

The Geology of South Africa

By Dr. Alex. L. du Toit. Edited and prepared for publication by Dr. S. H. Haughton. Third edition, revised and enlarged. Pp. xiv+611+41 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1954.) 63*s*. net.

THE late Alexander du Toit's "Geology of South Africa" first appeared in 1926 (*Nature*, 119, 665; 1927) and was followed by a second edition in 1939. Du Toit himself had almost finished the text of this new revised and enlarged edition at the time of his death in February 1948. The task of completing the revision, with the aid of certain notes left among the author's papers, and the preparation of the manuscript for the press were placed in the capable hands of Dr. S. H. Haughton.

While the text has been left essentially in the state in which the author prepared it, attention has been directed, by means of footnotes, to later work by South African geologists in which views have been expressed, particularly on problems of correlation, that differ materially from those of the author. The coloured geological map that accompanies the volume has been completely revised and redrawn under Dr. Haughton's supervision. Geologists everywhere will welcome the new edition of this standard and authoritative work.

THE SPECIES SPECIFICITY OF MYOGLOBIN

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Crystallographic Aspects

MYOGLOBIN is in many ways a very suitable protein for X-ray crystallographic studies, but has hitherto been scarcely a convenient one, since it is difficult to crystallize when obtained from the more common domestic animals. During a survey of less easily available animals—in particular the whales—we have found a number of new crystal forms of myoglobin, some of them very readily prepared. The main purpose of this survey was to discover crystals suitable for detailed study by X-ray diffraction, and accounts of such studies will be published elsewhere; however, the distribution of these forms among the species we have examined is also of interest from the point of view of species specificity and zoological relationship, and in the light of immunological studies described in the second part of this paper.

minced tissue with ice-cold water, and removing other proteins by treatment with lead acetate and by repeated recrystallization from ammonium sulphate and from concentrated phosphate buffer. Crystallization may be effected by salting-out from either of the latter media.

By methods of this kind, varying in detail from species to species, we have found some dozen crystal forms of myoglobin, all of which have been studied by X-ray methods. Of these (see Table 1) only the following have been previously described: horse myoglobin (type *C*), see Kendrew[4] and Kendrew and Trotter[5]; finback whale myoglobin (type *F*), see Schmid[3] and Kendrew[6]. Blue whale crystals of type *E* were first prepared by Dr. J. Keilin in 1951 and examined crystallographically by one of us[7]. The crystals of tortoise and carp myoglobins were first prepared by Hamoir[8] and Renard[9], and those used by us for X-ray analysis were made from

Table 1. Types of Myoglobin Crystal

Type	Principal source	Symmetry	Space group	Mol./cell	Cell dimensions (wet) a	b	c	β
A	Sperm whale* (from ammon. sulph.)	Monoclinic	$P2_1$	2	64·6 A.	31·1 A.	34·8 A.	105·5°
B	Sperm whale (from phosphate)	Orthorhombic	$P2_12_12_1$	4	48·9	40·2	79·3	
C i	Horse†	Monoclinic	$P2_1$	2	57·3	30·8	57·0	112°
	Seal‡	Monoclinic	$P2_1$	2	57·7	29·6	57·1	112°
ii	Seal§	Monoclinic face-cent.	$A2$	4	57·7	29·6	106·2	102°
iii	Horse	Monoclinic ψ-orthorh.	$P2_1$	4	57·0	30·8	106·0	91°
D	Blue whale	Orthorhombic	$P2_12_12_1$	4	33·9	60·4	76·6	
E	Blue whale	Orthorhombic	$P2_12_12_1$	12–16	144·5	37·7	107·5	
F	Finback whale	Orthorhombic	$P2_12_12$	4	97·4	39·8	42·5	
G	Gentoo penguin	Face-cent. orthorhombic	$C222_1$	8	48·3	80·2	78·5	
H	Gentoo penguin (imidazole deriv., phosphate)	Orthorhombic	$P2_12_12_1$	4	106·4	39·1	45·3	
I	Gentoo penguin (imidazole deriv., ammon. sulph.)	Orthorhombic	$P2_12_12_1$ (?)	4	94·5	38·3	43·5	
J	Carp	Orthorhombic	$P2_12_12_1$	4	55·0	46·5	51·7	

* A related lattice was obtained from tortoise (*Testudo graeca*), with space group $P2_1$, and lattice dimensions $a = 64·3$, $b = 30·2$, $c = 36·4$ A., $\beta = 105°$; the distribution of intensities is fairly similar to that of type *A*. A shrinkage stage of this lattice was observed.
† In addition, one shrinkage stage.
‡ In addition, one swelling stage.
§ In addition, three shrinkage stages.

In searching for promising sources of myoglobin, we have mainly investigated aquatic mammals, and birds which spend a good deal of time under water; the skeletal muscles of such animals often contain so much myoglobin that they are almost black in colour. We have found that whales (especially the sperm whale, *Physeter catodon*), seals and penguins are particularly rich sources; on the other hand, a specimen of dugong meat (kindly sent to us from Ceylon by Mr. J. W. S. Pringle) was very pale and contained little myoglobin.

The procedure used for extracting and purifying the myoglobin was a modification of that described by Morgan[1], Theorell and de Duve[2], and Schmid[3]; it consists in essence of extracting the myoglobin from

material supplied by them. Besides all these, the myoglobins of a number of species, including cow, man, ass, mule and pig, have been crystallized by Rossi-Fanelli, Theorell, Roche, Vieil, Drabkin and their associates; we have omitted these from present consideration since in no case have they been studied by X-ray methods.

We find that several different types of crystal may sometimes be derived from the same species of animal (see Table 2); often different forms are obtained according to the salt used for precipitation (for example, sperm whale gives type *A* in ammonium sulphate, type *B* in phosphate), while sometimes different derivatives of the protein crystallize in different forms (for example, myoglobin of gentoo penguin; as metmyoglobin in phosphate this gives type *G*, as imidazole-myoglobin it gives type *H*. In ammonium sulphate the met-compound refused to crystallize, while the imidazole derivative gave

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Table 2. DISTRIBUTION OF TYPES OF MYOGLOBIN CRYSTAL

	Types of crystal observed		Cross-reaction with anti-sperm-whale myoglobin	
			a	*b*
CETACEA				
Odontoceti (toothed whales)				
Physeter catodon (sperm whale)	*A*	*B*	+++	100
Phocaena phocaena (common porpoise)	*A*	*B*	+++	33
Tursiops truncatus (bottle-nosed dolphin)			++	
Mysticeti (whalebone whales)				
Balaenoptera musculus (blue whale)	(*A*)†	*D, E*	+++	(66)
Balaenoptera physalus (finback whale)	(*A*)†	*F*	+	(35)
Balaenoptera borealis (sei whale)	*A*		+++	36 (90)
Balaenoptera acutorostrata (lesser rorqual)	*A*		+++	
Megaptera nodosa (humpback whale)		*D*	+++	33
PINNIPEDIA				
Phoca vitulina (common seal)		*C*	+	
Zalophus californianus (Californian sea-lion)*			+	
OTHER ORDERS				
Equus caballus (horse)		*C*	0	
Testudo graeca (tortoise)	*A* (?)		0	
Pygocelis papua (gentoo penguin)		*G, H, I*	0	
Cyprinus carpio (carp)		*J*	0	

* Crystals obtained, but too small for X-ray analysis.
† Crystals of this form rarely obtained.

crystals of type *I*). On the other hand, we sometimes obtained virtually the same crystal form from two or more different species; by this we mean that the lattice dimensions were nearly identical, and the intensities of corresponding X-ray reflexions difficult to distinguish. In some cases (for example, type *A*) the resemblance is very close indeed; in others there may be appreciable changes in cell dimensions (for example, in type *C*, where horse myoglobin crystals have $b = 30{\cdot}8$ A. and seal crystals have $b = 29{\cdot}6$ A.), though the general resemblance is unmistakable. Tortoise myoglobin provides an example of a more distant relationship, its crystals showing a definite resemblance to crystals of type *A* but nothing approaching an identity; tortoise myoglobin crystals stand in the same sort of relationship to type *A* as would a shrinkage stage, if one were known. Crystals of type *C* form a most interesting group; as has been indicated in a recent paper[5], horse myoglobin generally forms pseudo-orthorhombic crystals having four molecules in the unit cell, this arrangement being derived by inversion of alternate sheets of molecules from a rare monoclinic form (two molecules/cell) obtained on one occasion only[4]. In the common seal as well we obtained two related forms: by crystallization from phosphate a monoclinic 2-molecule form closely resembling monoclinic horse myoglobin, and from ammonium sulphate a new face-centred 4-molecule monoclinic form derived from this by simple translation of alternate sheets of molecules in the *b*-direction instead of by inversion. The Patterson projections of these forms confirm these relationships, which will be discussed in detail elsewhere.

The close resemblances between certain crystal forms of myoglobins from different species provide justification for a comparative study of myoglobin structure using different types of crystal. The myoglobin molecules in sperm whale, in porpoise, and in four *Balaenoptera* species, all of them crystallizing in type *A*, must resemble one another extremely closely; indeed, from the still rather crude point of view of the X-ray analyst, one can certainly regard them as identical. These facts, taken together with the polymorphism of myoglobin from sperm whale and porpoise (types *A* and *B*), of blue whale (types *A*, *D* and *E*), and of finback whale (types *A* and *F*), mean that from this point of view we are entitled to assume the virtual identity of the myoglobin molecules present in types *A*, *B*, *D*, *E* and *F*, and to make comparative studies of these forms. Type *C* (horse and seal), types *G*, *H*, *I* (gentoo penguin) and type *J* (carp) still lie outside this system. In the absence of complete chemical analyses we cannot do more than guess at reasons for the slight but observable intensity differences between the diffraction patterns of, for example, type *A* crystals from different species; they are, however, of a magnitude which would be accounted for by differences of one or a few side-chains in the molecule. In monoclinic sperm whale myoglobin, differences of the same order of magnitude have been produced artificially by attaching an imidazole molecule to the hæm group prior to crystallization; but even so small an alteration in the molecule can sometimes produce a more extensive change in crystal habit. Thus in orthorhombic sperm whale myoglobin the imidazole derivative gives intensities so much changed from normal that one must assume an appreciable change in crystal packing, although the lattice constants are very slightly affected, if at all: in the gentoo penguin, as has already been pointed out, a complete change in crystal form is induced by the attachment of imidazole.

Immunological Aspects

The cross-reactions of the myoglobins of various species with antisera against sperm whale and seal (*Phoca vitulina*) myoglobins were studied by three methods:

(*a*) *Ouchterlony's method*[10]. Cup *A* (Fig. 1), which was cut out of a layer of agar in a Petri dish, was filled with antiserum; cup *B* with a solution of the homologous myoglobin (*M*) and cup *C* with a solution of another myoglobin (*M'*); the concentrations of the myoglobin solutions were about 0·02 per cent. Antigen and antibody diffuse into the agar and form a precipitate where they meet; the precipitate is soluble in excess of antigen, so that the band of

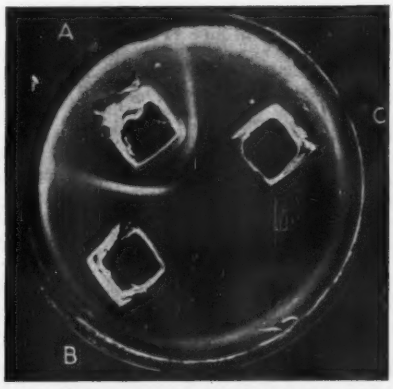

Fig. 1. Reactions of sperm whale and finback whale myoglobins with a solution of γ-globulin prepared from a pool of antisera against sperm whale myoglobin, demonstrated by Ouchterlony's method: *A*, γ-globulin solution; *B*, sperm whale myoglobin; *C*, finback whale myoglobin

precipitate is limited on the antigen side. If M and M' are identical, excess of antigen sufficient to inhibit precipitation is reached at the same place by antigen diffusing from B and from C: the left- and right-hand bands are continuous. If M' is similar to M and will precipitate some, but not all, of the antibody in the antiserum, excess with respect to the M'-antibody reaction will be reached before excess with respect to the M-antibody reaction: the bands will not be continuous (as in Fig. 1). The more similar M' is to M the more nearly will the right-hand and left-hand bands be continuous. If M' is so unlike M that it forms no precipitate with the anti-M serum, no band of precipitate will form on the right. Estimates of the degree of similarity of myoglobins of other species to sperm whale myoglobin, assessed in this way, are given in column *a* of Table 2.

(*b*) The maximum amount of precipitate formed by M' with anti-M serum can be used as another criterion of the immunological similarity of M' to M. The amounts of precipitates formed by various myoglobins with anti-sera against sperm whale myoglobin (expressed as percentages of the maximum precipitate formed by sperm whale myoglobin with the antisera) are given in column *b* of Table 2. The antisera used were from the same rabbit, bled on October 8 (1953) and March 12 (1954), after a further course of injections. The figures in brackets were obtained with the second sample of antiserum: it appears that, as is usual after more prolonged immunization, the second antiserum cross-reacted with heterologous antigens more strongly than the first.

(*c*) The antisera, particularly those against seal myoglobin, were rather weak. Concentrated solutions of γ-globulin were therefore prepared from the antisera, and rough visual estimates were made of the amounts of precipitate formed by the various myoglobins with these solutions; and the rates of flocculation of the anti-sperm whale myoglobin γ-globulin with various myoglobins (at optimum proportions) were compared.

As judged by these three criteria, the myoglobins may be classified into five groups, ranging from those in group (1) which cross-react very strongly with sperm whale myoglobin, to those in group (5) which do not cross-react at all: (1) porpoise, sei whale, and lesser rorqual; (2) humpback and blue whale; (3) dolphin and finback whale; (4) seal; (5) tortoise, horse, penguin and carp. (There is little distinction between groups (1) and (2).)

When sei whale or porpoise myoglobin was used in cup C in Ouchterlony's method, with certain samples of sperm whale antiserum in cup A, two distinct bands appeared on the right-hand side; on the left the separation of the bands are less definite. This is evidence that these antisera contain antibodies against two antigens in the sperm whale myoglobin and in the sei whale and porpoise myoglobins. The ratios of the two antigens in the sperm whale myoglobin to the two antibodies in the antisera were such that the points at which excesses of both antigens were reached almost coincided, whereas the ratio of the two antigens in the sei whale and in the porpoise myoglobins was slightly different. When the γ-globulin solution prepared from pooled antisera was used in cup A and a solution of finback whale myoglobin in cup C, three distinct bands were formed on the right-hand side (Fig. 1)—evidence of the presence in the γ-globulin of antibodies against three antigens. These results suggest that myoglobin as prepared from tissues by rigorous methods (which include repeated recrystallizations—in the case of the sperm whale antigen five times from ammonium sulphate and twice from phosphate) consists of more than one component: the same conclusion has previously been reached from electrophoretic studies[9].

The antiserum against seal (*Phoca vitulina*) myoglobin cross-reacted with myoglobins of other members of the same order (*Zalophus californianus*, *Mirounga peonina*, and another seal of unknown species), but not with horse myoglobin.

Kesztyüs and Várterész[11] obtained antisera against horse, ox, dog, pig and cat myoglobins; each formed a precipitate with myoglobin of the homologous species and not with the heterologous antigens. None of these species is as closely related as the members of the Cetacea. Comparable studies are those of Heidelberger and Landsteiner[12] and of Hektoen and his colleagues[13–15] on hæmoglobins; cross-reactions were found between horse, donkey and mule hæmoglobins, between human and rhesus hæmoglobins and between ox, sheep, goat and yak hæmoglobins.

Relationships of the Myoglobins

The range of purified myoglobins available from various animal species is now wide, and this protein would probably lend itself well to detailed investigations of species specificity. It is unfortunate that at present complete amino-acid composition data are available only for horse[16] and finback whale[17] myoglobins, and the molecular weight has been determined only for horse (there is, however, reason for supposing that the molecular weight of blue whale myoglobin is also about 17,000[18]; furthermore, all the X-ray data are consistent with this being the value in every species so far examined). But even without other data, the distribution of crystal forms shows features of interest. Thus type A crystals are widespread among whale myoglobins, and indeed they have been made from almost every species of whale the myoglobin of which has so far been crystallized; but it is remarkable that although the form is predominant in both the main groups—the toothed and the whalebone whales—there are two members of the whalebone genus *Balaenoptera* in which type A has been encountered only very rarely (myoglobin from *B. musculus* and *B. physalus* almost always crystallizes in type D, E or F), although these species are morphologically much more closely related to *B. borealis* and *B. acutorostrata* than are the toothed whales *Physeter catodon* and *Phocaena phocaena*—in all four of which type A is the predominant form.

This distribution of crystal forms is in accord with the immunological results which, as we have seen, also suggest a relatively closer resemblance between the myoglobins of certain whalebone whales and of the toothed whales, and a relatively greater dissimilarity between that of *B. physalus* and those of other members of the genus *Balaenoptera*, than would have been anticipated from the conventional morphological classification. On the other hand, myoglobins which have similar crystal forms are not necessarily similar immunologically; horse myoglobin did not form a precipitate with antiserum against the myoglobin of the seal *Phoca vitulina*, although both myoglobins give type C crystals.

Such chemical information as is available is not inconsistent with the findings of the present investigation. Terminal amino-groups have been shown (by the fluoro-dinitrobenzene method) to be present to

the extent of one per 17,000 molecular weight units in each of the four species of myoglobin so far investigated. In finback whale[17] and sperm whale[19] the terminal residue is valine; in horse[20] it is glycine, and one of us (E. S. O.) has recently found that it is also glycine in the seal *Phoca vitulina*. So far as it goes, the correlation is satisfactory; but it is clear that at present the relationships can only be incompletely grasped. One might, for example, have anticipated a cross-reaction between horse and seal myoglobins, and between those of sperm whale and tortoise, in conformity with the chemical and crystallographic relations. There is evidently a need for wider studies using chemical as well as immunological and crystallographic techniques, if a deeper insight is to be gained into the molecular basis of species specificity and morphological classification.

It appears from the ratio of antibody to antigen in the precipitates that one molecule of myoglobin can combine with three of antibody; thus there must be three combining groups on the myoglobin molecule. Some indication of the nature of these groups might be gained by comparative chemical studies; these could be directed in the first instance towards pairs of species such as, on one hand, the horse and the common grey seal, the myoglobins of which crystallize in closely related forms giving very similar diffraction patterns but do not cross-react; and, on the other hand, sperm and sei whale myoglobins, the crystals of which stand in a similarly close relation to one another, but which cross-react very strongly. As has been indicated, the chemical differences required to account for the differences in diffraction pattern might amount to one or two amino-acid residues; but they could as well be differences of sequence as differences of overall composition, so the chemical procedures required to detect them might be very laborious.

We are grateful to many individuals and institutions for assistance in obtaining samples of meat; among them are the Low Temperature Research Station at Cambridge (especially Dr. R. G. Sharp), Zoological Society (London), Dr. F. C. Fraser, of the British Museum (Natural History), Royal Scottish Museum, Hector Whaling, Ltd. (especially Mr. H. W. Symons), Pacific Steam Navigation Co., National Institute of Oceanography (especially Mr. R. Clarke), Prof. C. Monge, of the University of Lima (Peru), Prof. G. Hamoir, of the University of Liège (Belgium), Prof. R. J. Harrison, of the London Hospital Medical School. One of us (J. R. M.) gratefully acknowledges financial assistance from the Nuffield Foundation.

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ELECTRONIC BAND STRUCTURE OF SOLIDS

THE growing importance which government scientific establishments now attach to the theory of the electronic band structure of solids is shown by the holding of a conference on this subject at the Radar Research Establishment in Malvern during September 27–28. Besides members of the Establishment, there were representatives present from Harwell and Baldock, as well as from most of the universities in Great Britain.

It is now about twenty-five years since the idea of a band structure for the energy-levels of electrons in a crystal lattice was put forward by Bloch and others; and during this period, apart from certain stimulating but controversial ideas of Linus Pauling in the United States, this concept has dominated all theoretical discussions of metals, particularly of electrical conductivity and related effects. According to this approximation, the valence, or conduction, electrons are treated as moving, more-or-less independently of each other, in the electrostatic field produced by the positive nuclei and the average Coulomb potential of the various electrons. These electrons are allotted to energy-levels, which lie in bands, often—but not always—separated from each other, having forbidden energies between them. The density distribution $N(E)$ of these energies is fundamental for almost all later applications.

One of the earliest calculations of these energy-levels is the so-called cell model. In this model, we divide the space around each atom into cells, and within each cell (sometimes replaced by an effective sphere for convenience in manipulation) we solve the Schrödinger wave equation, using the potential field for an isolated atom, but replacing atomic boundary conditions by appropriate boundary conditions for the cell. But recently certain serious difficulties have become apparent. Thus, we have good reason for believing that over the greater part of the atomic cell —or polyhedron—the absolute magnitude of the wave function ψ is nearly constant, showing fluctuations only in the immediate vicinity of the nuclei. Now, the representation of an almost constant function within a polyhedron in terms of atom-like *s,p,d*, functions with correct boundary conditions is not easy; and it has been found necessary to use high-energy atomic orbitals. A further difficulty was pointed out by N. H. March (Sheffield), who showed, from a Thomas–Fermi statistical approximation in a diamond-type structure, that it is not adequate to use the spherically symmetrical atomic potential. Instead, the perturbations due to incipient chemical bonds affect the symmetry both of the potential and the wave functions by introducing higher-order angular terms.

More recently, the cell model has been replaced by an alternative, in which the potential is taken as constant over the metal, excluding a suitable spherical region around each nucleus. In this latter region it has the atomic value. Where the potential is constant, the wave function is that of a plane wave. But near the nuclei, ψ deviates considerably from this form. This method is referred to as the augmented plane-wave method. Dr. D. J. Howarth (Malvern) has extended this treatment, and, particularly for the important case of copper, has shown how, by combining two or more plane waves (equivalent to each other in the reciprocal lattice space), a

rapid convergence is obtained. It was previously supposed that too many terms would be needed to make this method usable. A further variant of this treatment has been introduced by R. S. Leigh (Harwell), who found that it is possible to work with wave functions within and without the nuclear spheres, which are not continuous at the boundary and the gradients of which are also discontinuous. This 'shocking' disregard of conventional usage seems to work much better than might have been expected.

Another alternative to the cell-model type of approach is the tight-binding method, familiar to chemists as the molecular orbital approximation. Dr. G. C. Fletcher (Exeter) described the application of this method to the 3*d* electrons in nickel, and the possibility of inferring ferromagnetic anisotropy factors. Dr. E. P. Wohlfarth (Imperial College of Science and Technology, London) showed how, if we accept the idea of an energy band, we may use experimental ferromagnetic curves to infer the shape of these bands. Dr. R. Barrie (Services Electronics Research Laboratory, Baldock) showed similar uses of thermoelectric power data, particularly in relation to semiconductors such as gallium–arsenic or indium–antimony, where the energy gap between bands is relatively small. Lattice scattering was discussed by J. M. Radcliffe (Malvern), and Dr. S. L. Altmann (Oxford) gave a general discussion of the way in which the non-localized orbitals may be replaced by an equivalent set of localized, or Wannier, functions.

So far we have accepted the fundamental concept of an energy band; but this is now under serious scrutiny. For the electrons affect each other, and there are large exchange forces between electrons of similar spin, which are different from those between electrons of opposite spin. If this is a significant difference, the basis on which calculations are made is entirely changed. It is believed that just this situation does arise in antiferromagnetism, where electrons of one type of spin tend to collect on certain sites, whereas electrons of the other type congregate around the alternate sites. Clearly the form of the effective one-electron potential is crucial. Dr. G. G. Hall (Cambridge) discussed this on the basis of the Hartree–Fock type of wave function, showing among other things that the presence of an exchange force should lead to a different potential for occupied and unoccupied states. The relevance of this for all discussion of X-ray absorption spectra, in which an electron is lifted from a lower (atomic) level to one of the previously unoccupied conduction levels, is obvious.

A second criticism of the simple band theory came from R. J. Elliott (Harwell), who showed that the spin-orbit coupling of the conduction electrons, almost always neglected in calculations of this kind, is not really negligible, and can easily amount to 0·4 eV. in particular cases. In addition, Dr. S. Raimes (Imperial College, London) indicated that the recent theory of Bohm and Pines, in which long-range correlation of electrons is taken account of in terms of so-called plasma oscillations, also affects the shape of the $N(E)$ curve. Not only does it give a far more satisfactory shape than the Hartree–Fock approximation, but it also reduces the calculated band-width, as seems to be required to agree with experiment, and also leads to the possibility of a 'tail' in the soft X-ray emission curve. Such tails exist, and have been a source of considerable perplexity to the experimentalist who tries to interpret them in terms of a conventional band concept. This explanation may easily provide a way out of the difficulty.

A final criticism of the one-electron picture came from J. Hawgood (Newcastle), who showed how to apply the molecular theories of configurational interaction to a simplified 'linear' metal. The number of configurations to be considered is enormous, reminiscent of the number of canonical structures in organic chemistry. But sufficient progress has been achieved to suggest that this is a hopeful line of approach.

The foregoing account should make it clear that no strikingly new theories have been put forward. But at long last, it looks as if we are beginning to understand both the limitations of any band theory of the electrons in a metal, and also the type of numerical and algebraic technique that is likely to prove most effective in handling the problem on the assumption that a band model is legitimate.

C. A. Coulson

ABRAHAM DE MOIVRE (1667–1754)

TWO hundred years ago, on November 27, 1754, the death occurred in London of the Huguenot refugee, Abraham de Moivre, whose name is best known from his theorem in analytical trigonometry. But perhaps more important were his contributions to the theory of probability, which, according to Todhunter, owes more to him than to any other mathematician, with the sole exception of Laplace.

The son of a surgeon, de Moivre was born on May 26, 1667, in Vitry, France. He was at first educated by the Christian Brothers, but at the age of eleven entered the Protestant University of Sedan. His studies were continued at Saumur and Paris, but were suddenly interrupted in 1685 by the revocation of the Edict of Nantes and his seclusion in a priory. On his release in 1688 he went to London, with a letter of recommendation to the Earl of Devonshire, at whose house he heard of Newton's "Principia". In 1692 he met Halley and soon afterwards Newton, who esteemed him very highly, and in his later years used to reply to inquiries about mathematics and the "Principia": "Go to Mr. de Moivre; he knows these things better than I do". De Moivre contributed a paper on fluxions to the Royal Society in 1695 and was elected a Fellow in 1697. In 1712 the Royal Society appointed him to the committee to report on the Newton–Leibniz controversy.

De Moivre's first publication on probability was "De Mensura Sortis" (1711), which extended de Montmort's essay on games of chance. The more important "Doctrine of Chances" (1718) dealt with the probability of a compound event and with many particular problems. De Moivre was second only to Halley as a founder of the theory of life contingencies, and his "Annuities on Lives" (1725), which was much used by actuaries, ran into several editions. The "Miscellanea Analytica" (1730) included analytical trigonometry, recurring series, problems of chance, and analysis applied to astronomy. It contained something equivalent to 'De Moivre's theorem', though the usual form of this theorem was not explicitly stated, and there was also 'De Moivre's property of the circle'. These trigonometrical results were the development of the work of R. Cotes. Many copies of the "Miscellanea Analytica" contain a supplement which ends with a table of fourteen-place

logarithms of factorials. But a second supplement, dated 1733, is so rare that it was unknown to most authorities until described by Karl Pearson[1]; this contained the first treatment of the probability integral and essentially of the normal curve, long before the discussions by Laplace and Gauss. De Moivre also discovered what is usually known as Stirling's theorem, an approximate formula for the factorial of a large number; he communicated the result to Stirling, who then obtained an alternative proof and a slightly improved form. What is now known as Bernoulli's theorem was only partially due to Bernoulli, for it was completed by de Moivre.

The "Miscellanea Analytica" brought fame to its author and his election as a member of the Berlin Academy. Unfortunately, in spite of de Moivre's many influential admirers, the fact that he was of French birth prevented him from attaining any satisfactory appointment, either in Britain or Germany. He supported himself by private tuition and lectures, and in his old age earned a precarious living at Slaughter's Coffee House by solving problems on games of chance for its aristocratic frequenters. A few months before he died he was elected an associate of the Paris Academy of Sciences.

[1] *Biometrika*, **16**, 402 (1924), and **17**, 201 (1925).

USE OF RADIOACTIVE ISOTOPES IN SMALL-MAMMAL ECOLOGY

By GILLIAN K. GODFREY
(Mrs. Crowcroft)
Zoological Society of London

MANY problems in animal population studies require for their solution knowledge of the range of movement of individuals. Repeated live-trapping of marked animals is the usual technique employed, though with birds and the larger mammals visual observation is often possible. The availability of a wide range of radioactive isotopes has enabled certain animals, especially insects, to be marked in a novel and efficient manner. Radioactive isotopes also promise to be of great value for obtaining direct information about the movements of a single individual.

The first recorded use of radioactive material in tracing the movements of an animal is by Tomes and Brian[1,2]. Female click beetles (*Agriotes*) were labelled with radium sulphate which was sandwiched between aluminium disks and fastened beneath the elytra. The beetles, which could be detected through three inches of soil, were located periodically with a Geiger–Müller counter. Daily movements were of the order of twelve inches. Certain other insect studies have involved the actual incorporation of the radioactive isotope into the tissues[3,4].

It is difficult to obtain information about the movements of small mammals as they are relatively mobile and carry out most of their activities in dense cover or below ground. It is known that live-trapping may produce both physiological and psychological effects, the former being seen in abnormal movements after release, and the latter in changed behaviour towards traps. By trapping a small mammal once only, attaching a radioactive source and following it about with a portable Geiger–Müller counter, it is possible to make a large number of observations without disturbing it further. Clearly, the size and habits of the species will determine whether or not this method is practicable: for example, it will not be applicable to the study of a large, highly mobile mammal like the fox.

The method was applied in 1949, however, to a study of the movements of the field vole (*Microtus agrestis*)[5]. A high-energy gamma source was required as the animals had to be detected through tall, dense grass (*Brachypodium*) and at times within shallow burrows. Cobalt-60 was chosen as it was available in a convenient form and had a long half-life (5·3 yr.). Each vole was labelled with 80–100 microcuries enclosed in a brass capsule which was soldered to a nickel leg-ring. The Geiger–Müller tube was mounted at the end of a 6-ft. rod, and as the source could be detected (through headphones) 3–4 ft. from the tube, the animal could be located at a distance of up to 12 ft. from the observer. By locating an individual at frequent intervals, a clear picture of its range of movement could be obtained. Labelling pregnant females with radioactive rings also proved a useful means of locating nests containing young[6]. Similar work has been attempted in America using meadow voles (*Microtus pennsylvanicus*) injected with beta-emitting radioactive phosphorus (L. Miller, personal communication). This method depends upon locating radioactive fæces, and appears to be of limited use for work on small mammals.

Radioactive labelling is currently being utilized in an ecological study of the mole (*Talpa europaea*), financed by the Nature Conservancy. A larger version of the ring used for *Microtus* is fitted around the base of the mole's tail, where it does not interfere with movements or digging. A source of 80 microcuries has proved sufficient in spite of soil absorption, for in the absence of tall vegetation the probe can be held immediately above the soil surface. Because of the mole's reputed sensitivity to vibration, a longer handle was fitted to the probe to enable the animal to be located at a greater distance.

The determination of the range of movement is only the first step in investigating the animal's relationship with its environment. The next step is clearly an attempt to find out how the individual obtains and expends its energy within its range. Live-trapping has proved an inadequate means of showing how the various parts of the range are used, and which areas within the perimeter are, in fact, not used at all. The way in which the animal distributes its activities in time must also be investigated. The ability to keep in almost continuous contact with a mole labelled with radioactive material means that, in this species at least, a start can be made on the simpler aspects of these problems. The animal's confinement within a discrete tunnel-system, much of which is visible on the surface, greatly simplifies the procedure of following it about. In practice, the actual paths taken as it moves about are marked with numbered pegs and afterwards recorded in detail. In this way a fairly accurate estimate of the linear distances moved in successive periods can be obtained. In addition to providing information about movements, long periods of continuous observation have revealed the nature of the mole's activity rhythm.

Before using radioactive labelling on a large scale, much thought must be given to possible immediate or long-term effects on the health and consequently the behaviour of the animals. Some of the theoretical considerations involved in estimating permissible dosages have been discussed by Griffin[7]. Where

there is any danger of substantial loss of rings through predation, isotopes with a short half-life are obviously preferable. It is extremely unlikely, however, that predators will be affected when metal rings are used, as these are either rejected, regurgitated, or passed with the fæces. Nevertheless, the choice of a study area should take into account not only the range of the species being labelled, but also that of any possible predator. In the present work on moles, most of the rings have now been removed from the animals, which have shown no signs of ill-health.

A drawback of the technique is that it is impossible to distinguish between labelled individuals with overlapping ranges. Although this limits its use, there are many important population problems, which by their nature can only be studied at the individual level, and for these it promises to be of valuable application.

[1] Tomes, G. A. R., and Brian, M. V., *Nature*, **158**, 551 (1946).
[2] Brian, M. V., *J. Anim. Ecol.*, **16**, 210 (1947).
[3] Hassett, C. C., and Jenkins, D. W., *Science*, **110**, 109 (1949).
[4] Kettlewell, H. B. D., *Nature*, **170**, 584 (1952).
[5] Godfrey, G. K., *Ecol.*, **35**, 5 (1954).
[6] Godfrey, G. K., *J. Mammal.*, **34**, 503 (1953).
[7] Griffin, D. R., *Ecol.*, **33**, 329 (1952).

OBITUARIES

Dr. Philip Eggleton

By the death of Dr. Philip Eggleton on October 7 at the early age of fifty-two, medical science has lost one of its most versatile and original minds and the University of Edinburgh one of its most stimulating and popular teachers.

Eggleton received his undergraduate and post-graduate education at University College, London. After graduating with honours in chemistry in 1922, he joined the Department of Physiology and Biochemistry, where he studied for two years under Prof. E. H. Starling, Sir William Bayliss and Sir (then Prof.) Jack Drummond. In 1925, following a brief experience in industry, Eggleton returned to University College with a grant from the Medical Research Council to work on certain of the chemical aspects of muscular contraction under the direction of Prof. A. V. Hill. The following year he was awarded a Beit Memorial Fellowship to continue his work in this field.

During this period, Eggleton (with Grace P. Eggleton) carried out his now classical work on the phosphorus compounds in muscle, which culminated in the almost simultaneous discovery by Fiske and SubbaRow and by himself of creatine phosphate (phosphagen) and in the recognition of the importance of the latter in the chemistry of the contractile process. The part played by Eggleton in what has been termed "The Revolution in Muscle Physiology" (A. V. Hill) was a most distinguished one, and it was fitting that in 1931 he was awarded the Julius Mickle Fellowship by the University of London for the most outstanding research in medical science carried out in the University during the preceding five years.

In 1930 Eggleton went to Edinburgh as lecturer in biochemistry in the Department of Physiology, and in this capacity and as senior lecturer and reader served the University under no fewer than four professors of physiology. On three separate occasions he was acting-head of the Physiology Department for long periods. At Edinburgh, Eggleton developed his great potentialities as a teacher to the full, and soon became one of the most lucid and stimulating lecturers in the University. He also developed a remarkable facility for explaining scientific matters to the layman in vivid and readily understandable language; and, since he was convinced of the value of some knowledge of the aims and methods of science in the general education of everyone, it was natural for him to become actively interested in the popularization of science. In collaboration with Prof. W. O. Kermack, he wrote an excellent popular book, "The Stuff We Are Made Of", and for many years he acted as adviser to the B.B.C. in Scotland on scientific broadcasts. His own broadcast talks were models of what such talks should be.

An important part of Eggleton's duties at Edinburgh consisted in giving help and advice on many different chemical matters to his colleagues in the Physiology Department. Because of this, and also possibly because of his own inclinations, his interests in biochemistry and in science generally broadened very considerably. He extended his knowledge of mathematics, and latterly became interested in rheological problems in biology. Possibly his own career as a creative scientist might have been more spectacularly successful had he been less catholic in his interests and had he been less unselfish in his attitude to his colleagues. However, those who were closest to him know that he was always happiest when helping others.

During the Second World War, Eggleton collaborated in research in the Physiology Department under the direction of Prof. I. de B. Daly on phosgene poisoning on behalf of the Ministry of Supply, and on decompression problems on behalf of the Air Ministry. He joined the Edinburgh Gas Identification Service (Civil Defence) and became deputy district gas adviser for South-East Scotland.

Eggleton was a member of the Physiological Society, the Biochemical Society and the Society for Experimental Biology. He served on the committees of all three bodies. He was also a member of the Joint Committee on Rheology of the International Council of Scientific Unions, and he organized the First International Colloquium on Physiological Problems in Biology, which was held in Sweden in 1950.

G. F. Marrian

Dr. G. P. Douglas, O.B.E.

The death of Dr. G. P. Douglas on October 16 at his home at Camberley will be regretted by a wide circle of friends.

Born in 1892, he was educated at George Watson's College, Edinburgh, and graduated in 1914 from the University of Edinburgh with distinction in engineering. He served in the First World War and was awarded the M.C.; in July 1916 he was wounded, suffering the loss of his leg. In December of that year he joined the Royal Aircraft Factory (now Establishment), where he was concerned in the building and running of the 7-ft. wind tunnels which were to supplement the single 4-ft. tunnel that was then the sole equipment. In 1918 he became engineer in charge of the wind tunnels, and played a formative part in the development of model work at the Establishment. He had a genius for using simple means, lucidity as to the range of validity of these means, and a keen appreciation of the need for flexibility in

method. During this period the 5-ft. and 24-ft. tunnels came into use.

In 1934 he became head of the Aerodynamics Department, of which the model work was one section. He played a big part in building up a strong department, more elaborate equipment, and enlarged field of work called for by the Second World War.

Dr. Douglas served on the council of the Royal Aeronautical Society during 1946–51, and for many years on the Aerodynamics Committee of the Aeronautical Research Council. He extended his contacts by attending the main international congresses on aerodynamics. He retired in March 1953. Though he would never allow the handicap of his lameness to keep him from clambering about aircraft, balloon shed roofs, ships, or anywhere else where his work lay, he had to pay for the effort involved by sacrificing many other activities. By the time of his retirement, he was over-strained by his unremitting devotion to duty.

To many of us, Dr. Douglas's greatest achievement lay in his personal influence in shaping the Department. He was honest to the core, humble as to his own attainments, and whole-heartedly pleased at the advance and achievement of the many distinguished people who served under him for various periods as young men. Under three ministries, he maintained to a very high measure the Aerodynamics Department as a place where scientists could grow up and develop their own type of ability, with the minimum of restrictive organization. F. B. BRADFIELD

Mr. Fred Lincoln

FRED LINCOLN, who has just died at the age of seventy-seven, must have been by far the most widely known laboratory assistant in the world. Almost all the leading physicists in the Commonwealth and many in other countries have worked in the Cavendish Laboratory at one time or another, and to all of them Lincoln was one of its main institutions. He joined the staff as a laboratory boy in 1893, and when I was a student Lincoln had already been the head assistant for many years. When I returned to Cambridge thirty years later as Cavendish professor, there was Lincoln in the same position and quite unchanged in appearance and energy. His fierce eye and even fiercer moustache still induced a very proper respect in the young research worker applying to him for apparatus or stores, and the kindness, humour and loyalty to the Laboratory, which had earned our admiration and affection, were the same as ever. When a presentation was made to him on the occasion of his retirement, contributions came from physicists all over the world, who will now be sad at the passing of a great figure and a warm friend. W. L. BRAGG

NEWS and VIEWS

Royal Society : Award of Royal Medals

H.M. THE QUEEN has been graciously pleased to approve recommendations made by the Council of the Royal Society for the award of the two Royal Medals for the current year as follows: Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell, for his distinguished work on nuclear and atomic physics; Prof. H. A. Krebs, Whitley professor of biochemistry in the University of Oxford, for his distinguished contributions to biochemistry.

Chemistry at Aberdeen : Dr. G. M. Burnett

DR. G. M. BURNETT, at present lecturer in chemistry in the University of Birmingham, has been appointed to the chair of chemistry in the University of Aberdeen at the early age of thirty-three. Dr. Burnett succeeds Prof. R. M. Barrer, who has gone to the Imperial College of Science and Technology, London (see *Nature*, July 31, p. 205). Educated at Robert Gordon's College, Aberdeen, he graduated with first-class honours in chemistry at Aberdeen in 1943. Owing to war-time requirements, he became an assistant in the Physics Department at Aberdeen, with special responsibility for dealing with the supplies of radium for the hospitals in the north-east of Scotland. In his meagre spare time at that period, he started research on the problem of determining the absolute rate constants and radical concentration in liquid-phase free-radical polymerization reactions. He very quickly succeeded in obtaining an exact solution to this problem, and was in fact the first to do so. The extension and exploitation of this work have been his main preoccupation during his stay in Aberdeen and, since 1948, in Birmingham. Dr. Burnett has written many papers covering all aspects of this field, and these have culminated in the publication of a book on polymer reactions, which forms a landmark in describing and reviewing critically this important branch of polymer chemistry and reaction kinetics.

Pure Mathematics at Birmingham : Prof. C. A. Rogers

DR. C. A. ROGERS has been elected to the Mason professorship of pure mathematics in the University of Birmingham in succession to Prof. R. A. Rankin, who has gone to Glasgow (see *Nature*, April 3, p. 615). Dr. Rogers, who is thirty-three, graduated at University College, London, in 1941, and after war service in the Applied Ballistics Department (Ministry of Supply) returned to that College as a research student in 1945. He was appointed assistant lecturer in 1946 and lecturer in 1949. The title of reader in mathematics was conferred on him in 1953. Dr. Rogers was awarded a Commonwealth Fund Fellowship in 1949 and spent the session 1949–50 at the Institute for Advanced Study, Princeton. Dr. Rogers has published some forty papers, many of which are substantial memoirs. Most of his work has been on the theory of numbers, and in particular on the geometry of numbers. In 1947 he gave a new and simple proof (*Ann. Math.*, **48**, 367; 1947) of the theorem of Minkowski and Hlawka, and this has proved to be the starting-point for much later work by himself and others. In a memoir published in *Acta Math.*, **82**, 185 (1950), he applied to the geometry of numbers a new inequality obtained by solving an integral equation. Jointly with A. Dvoretzky he has solved an outstanding problem in the theory of Banach spaces (*Proc. U.S. Nat. Acad. Sci.*, **36**, 192; 1950). Dr. Rogers's work has given him an international reputation as a pure mathematician, and he is also well known to many for his work in statistics and for his wide interests in science generally.

Veterinary Research in Mexico by the University of Pennsylvania

A co-operative research affiliation has been established between the School of Veterinary Medicine of the University of Pennsylvania and the Institute of Livestock Research (Institute de Investigaciones) at Palo Alto, near Mexico City, of the Mexican Government, and 18,000 dollars is being supplied by the United States Foreign Operations Administration to support the project. E. R. Squibb and Sons of Mexico, a subsidiary of the Olin Mathieson Chemical Corporation, New York, and E. R. Squibb and Sons, New York, are also participating and will assist in financing the undertaking. Prof. G. W. Rake, research professor of microbiology in the University of Pennsylvania, will direct the research work for the University at Palo Alto; before going to Philadelphia a year ago, he was director of the Squibb Medical Division for four years, and for twelve years previously headed the Microbiology Division of the Squibb Institute for Medical Research. Among the research workers from the Veterinary School in Philadelphia who are to be sent to Palo Alto will be Dr. Carlos Espana, who was born in Mexico and is a graduate of the University of Mexico. The Institute at Palo Alto, which was established in the 1940's mainly for combating foot-and-mouth disease, has four laboratory buildings, one large combination laboratory–administration building and thirty-six isolation units suitable for handling large farm animals; a main laboratory has been set aside for the Pennsylvanian workers and will be known as the Squibb–Mathieson Laboratory for Veterinary Research of the Ministry of Agriculture and Husbandry in Mexico and of the University of Pennsylvania. The first investigations to be made at this Laboratory will be one of the blood disease anaplasmosis, which is an infectious condition of the red corpuscles, and, later, studies will probably be made of shipping fever and brucellosis. The University of Pennsylvania plans to increase greatly the number of fellowships it offers for postgraduate training and, in particular, in return for the facilities at Palo Alto it will offer places for the training of Mexican veterinary workers and other scientists interested in infectious diseases affecting animals, with especial emphasis on those diseases transmissible to man. In conjunction with these new developments in Mexico, a dedicatory meeting was arranged in Palo Alto on November 17, and at the same time the annual conference of the Associated University of Pennsylvania Clubs was held in Mexico City.

Long Ashton Research Station: Report for 1953

The annual report of the Agricultural and Horticultural Research Station, Long Ashton, for 1953 (from the Station at Long Ashton, Bristol; pp. 218+13 plates; 1954; 15*s*.) is of particular interest as it records the jubilee celebrations held in July of that year, and includes speeches made by Sir Thomas Dugdale, Lord Bledisloe, Mr. Christopher Norbury and Prof. T. Wallace on that occasion. The special jubilee lecture delivered by Lord Rothschild has already been published in the commemorative volume "Science and Fruit". The research work carried out during the year falls into five main categories: pomology, plant nutrition (including that under the Agricultural Research Council Unit for Micronutrients), plant pathology, cider and fruit juices, and domestic food preservation. Among the numerous subjects under investigation, mention may be made of a survey of perry pears in the West Midlands, carried out in view of the increased interest in this beverage. A number of varieties are described and illustrated, and an attempt has been made to sort out the confusion of synonyms. Spray application problems form the subject of a group of papers. A method is described for use in estimating the penetration of DDT into plant tissues, and the times, strengths and formulations for DDT and BHC given for control of apple and plum aphids and of BHC for apple sawfly. A combined DDT–BHC emulsion has also been prepared. Field trials have been carried out with airflow mist spraying, a technique aimed at reducing both costs and risk of crop damage. Though the method was successful with DDT and BHC emulsion against plum and apple aphid and apple sawfly, similar applications of lime sulphur failed to control red spider, woolly aphid or apple scab.

Geophysics in Canada during 1953

The first volume of the series "Canadian Geophysical Bulletins", an annual review of activity in geophysical research and applied geophysics, published by the Associate Committee on Geodesy and Geophysics of the National Research Council of Canada, appeared in January 1947; the latest volume, Vol. 6, was published in December 1953, but has only comparatively recently been received here (pp. 73. Ottawa: National Research Council of Canada, 1953). It includes a bibliography of papers published during the year under review, either by Canadian workers in the field or by scientists from other countries, relating to Canadian problems. Short descriptions are given of nine papers on geodesy (including gravity), forty-two on seismology and the physics of the earth's interior, twelve on meteorology and hydrology, forty-nine on terrestrial magnetism and atmospheric electricity, and forty-two papers on oceanography. In December 1953, thirty-eight companies were known to be operating a total of about a hundred and fifty seismic prospecting parties in British Columbia, Alberta, Saskatchewan and Manitoba. Noteworthy is the publication by W. C. Gussow of the detailed geological, seismic and gravimetric studies of New Brunswick which were conducted for the Shell Oil Company (*Bull. Amer. Assoc. Pet. Geol.*, **37**, 1713; 1953).

Catalogue of Polish Scientific Literature, 1945–49

Vol. 21 of the "Catalogue of Polish Scientific Literature" (pp. 441. Krakow: Polska Akademii Nauk) covers the years 1945–49 and bears the date of publication 1952, though it has only recently been received. It is the first to appear since that for the years 1931–34, but Vol. 20, covering the years 1935–39, will be published later. The entries are given alphabetically by authors in eleven main sections—mathematics, physics, astronomy, terrestrial sciences, botany, microbiology, zoology, archæology, geography, technology—with a miscellaneous section, and some sub-sections such as chemical technology. There is also an author index and a list of Polish periodicals from which entries are taken, with the abbreviations used, and which includes 254 items.

Science Masters' Association: Meeting in Newcastle upon Tyne

The annual meeting of the Science Masters' Association will be held in King's College, Newcastle upon

Tyne, during December 28–31, the annual business meeting of the Association being on December 30 at 5.15 p.m. Dr. C. I. C. Bosanquet, rector of King's College, will deliver the presidential address to the Association on the evening of December 28, his subject being "In Praise of Natural Philosophy", and the Science and Citizenship Lecture will be given on the evening of the next day by Dr. Eric James, High Master of Manchester Grammar School. Besides the usual lectures in the morning on various scientific topics and informal visits to laboratories, there will be a discussion on the teaching of electricity, with special reference to M.K.S. units, on the morning of December 30, and another the next day on the teaching of science in secondary modern schools. As in the past, manufacturers and publishers who advertise in the *School Science Review* will be showing exhibits, and the usual members' exhibition of apparatus and teaching aids which members of the Association have found useful will also be held. The Northern Area Lighting Service Bureau of the Electric Lamp Manufacturers' Association has arranged to prepare an exhibition entitled "The Practical Aspects of Light and its Production", and the British Iron and Steel Federation will be showing some of its educational material. In the afternoons a number of excursions will be made to various works. Tickets are necessary for these visits and can be obtained from A. Hill, Hookergate Grammar School, Rowlands Gill, Co. Durham; they must be claimed by December 11. All other correspondence should be sent to the Annual Meeting Secretary, W. H. Dowland, 93 Westbourne Road, West Hartlepool, Co. Durham.

Physical Society: Annual Exhibition

THE Physical Society's annual exhibition of scientific instruments and apparatus will be held in the New Hall of the Royal Horticultural Society, Westminster, during April 25–28, 1955. About a hundred and forty exhibitors are expected to take part, including the usual number of university departments and government establishments, and the exhibition will also include scientific books and journals. The handbook of the exhibition will be on the same lines as those of previous years, with a large advertisement section which is open to all firms with scientific interests, whether taking part in the exhibition or not. The change of venue from the Imperial College of Science and Technology, London, to the Royal Horticultural Society's New Hall will in no way change the character and purpose of the exhibition; the space in the New Hall is by its nature more compact than that which has hitherto been available, and it is hoped that this will help visitors to see the exhibits more advantageously in a shorter time. Further information can be obtained from the Honorary Exhibition Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Swedish Academy of Engineering Sciences: Awards

THE Swedish Academy of Engineering Sciences has awarded four Gold Medals and its Brinell Medal for contributions in various scientific and technical fields. The Gold Medals have been awarded to the following: Mr. Erik Stemme, the principal scientific worker in a team that in three years has built the binary electronic computing machine BESK, the dielectric punched ribbon reader and certain details in its magnetic memory being the results of personal inventions by Mr. Stemme; Mr. Gunnar Jancke, for his role as a leading engineer in the designing and carrying out of a new network of high-tension electric cables which transmit current at 380,000 V. from the Lapland waterfalls to the central and southern parts of Sweden; Dr. Erik Bergstrand, for designing the geodimeter, an instrument for measuring geographical distances in terms of the time taken by light to traverse the distance, and which, incidentally, has been used in reverse to obtain an accurate measure of the velocity of light; and Mr. Olle Wernholm, for his work in perfecting electron accelerators. The Brinell Medal of the Academy goes, for the first time to a non-Swede, to Prof. John Chipman, of the Massachusetts Institute of Technology, for his achievements in the fields of metallurgy and metallography.

Announcements

DR. H. J. EYSENCK, reader in psychology with special reference to psychiatry in the Institute of Psychiatry, University of London, has been appointed to the University chair of psychology tenable at the Institute.

APPLICATIONS are invited for the Drummond fellowship for research in nutrition, which will be awarded about March next year. The fellowship is worth £900 a year, normally tenable for two years, with up to £50 a year research expenses and £90 superannuation. Application forms, to be returned by January 15, and further information can be obtained from the Honorary Secretary, Drummond Trust, University College, Gower Street, London, W.C.1.

THE Royal Society of New Zealand is offering a T. K. Sidey Summer-time Award, consisting of a bronze medal and prize of £100 (New Zealand currency), for scientific research on any kind of electromagnetic radiation (visible or invisible), including its relation to human welfare. Applications must be submitted by February 28, 1955. Further information can be obtained from the Secretary, Royal Society of New Zealand, Victoria University College, Wellington, W.1.

THE Sabena International Prize, which was established in 1953 to mark the thirtieth anniversary of Sabena Belgian Airlines, is awarded in alternate years to an artist or research worker, less than thirty years of age and of either sex, who wishes to extend his or her general knowledge by travel-study in the Belgian Congo or the United States. The subject of this year's competition is "Aviation and Social Geography", and entries must be submitted by March 31. The prize is worth 75,000 Belgian francs (just over £500). The conditions of the competition and further information can be obtained from Sabena Belgian Airlines, Air Terminus, Brussels.

IN an article discussing agricultural research in *Nature* of October 9, on p. 664 it is stated that "the Department of Scientific and Industrial Research . . . draws its revenue largely from industrial concerns". This is, of course, incorrect; the Department supports the research associations, and it is these associations which receive a major proportion of their revenues from industry.

IN the advertisement supplement in *Nature* of November 13, p. ix, the telephone number of Teleonics (Communications), Ltd., is incorrect; we are asked to state that the correct number is Fulham 1534.

ARCHÆOLOGY IN THE LABORATORY

A CONFERENCE convened by the Council for British Archæology under the title "Archæology in the Laboratory" was held on April 9 in the rooms of the Society of Antiquaries of London, at Burlington House. The proceedings of the conference have only recently become available.

Dr. C. B. M. McBurney (University of Cambridge), in his introduction for the Council, explained that, since its formation in 1944 as the co-ordinating body for archæological research, the Council has been anxious to explore the various possible applications to archæology of the methods and results produced in other scientific fields. A Natural Sciences Panel was accordingly set up and had prepared the "Notes for the Guidance of Archæologists in regard to Expert Evidence" published in 1947. Not only are the "Notes" now out of date, but also the rapid acceleration of developments in science and technology has made it necessary to re-examine the whole matter with regard to both scope and organization. There is also the reverse aspect, not hitherto considered systematically, where the archæologist could provide the scientific research worker with valuable material in a context that could be precisely defined and is independently datable.

The Council had been considering a proposal, made earlier in the year by Mr. L. Biek (Ministry of Works), to establish a permanent Scientific Research Committee for Archæology. This was, in particular, to facilitate the flow of material sent from archæological excavations for expert examination and to collate the results, and generally to provide a clearing house for information and ideas of mutual value to archæologists and other scientists. The scheme was welcomed by archæologists and, at the suggestion of Sir Mortimer Wheeler (University of London), the Council had decided to invite scientists to give their views on the proposal. Dr. McBurney said he was asking if they considered it to be desirable and practicable, and what they felt about the reciprocal value, to themselves, of this type of work. He was further asking for details of recent advances, and for suggestions about improving and extending investigations as at present carried out, in the principal fields which had been selected for discussion, namely, petrology of stone implements and ceramics, building research, soil science, pollen analysis and other botanical examination, ecology, conchology, animal and human osteology, physical and chemical tests, and metallurgical and corrosion studies.

The following then gave their views: Mr. E. M. Jope (The Queen's University, Belfast), Prof. F. W. Shotton (University of Birmingham), Dr. F. S. Wallis (Bristol Museum), Mr. M. Davies (British Iron and Steel Research Association), Mr. H. Barker, Dr. F. C. Fraser and Dr. K. P. Oakley (British Museum), Dr. N. Davey and Dr. H. G. Midgley (Building Research Station, Department of Scientific and Industrial Research), Mr. R. M. Cook (Cambridge Museum of Classical Archæology), Dr. H. Godwin, Dr. S. K. Runcorn and Dr. J. C. Trevor (University of Cambridge), Mr. T. W. Farrer (Chemical Research Laboratory, Department of Scientific and Industrial Research), Dr. W. H. J. Vernon (recently of the Chemical Research Laboratory), Dr. F. Y. Henderson (Forest Products Research Laboratory, Department of Scientific and Industrial Research), Dr. P. A. Sabine (Geological Survey), Mr. C. F. M. Fryd (Department of the Government Chemist), Prof. R. D. Preston (University of Leeds), Dr. I. W. Cornwall, Prof. F. W. Jane and Prof. F. E. Zeuner (University of London), Mr. H. H. Coghlan (Newbury Museum), Dr. E. T. Hall (University of Oxford), and Dr. J. S. Weiner (Oxford University Museum).

With certain notable exceptions in the fields of metallurgical and palæomagnetic analysis, where more or less specific schemes are operating to less than capacity and samples are indeed welcome, it seems that there is a general lack of man-power if not, in most cases, of equipment. Nevertheless, work in all the other fields is proceeding well. Important advances have been made in applying the use of 'white' X-rays to the study of unknown materials. Pollen analysis has been expanded to include herbaceous plants and to give information about methods of husbandry. Full details were given about a 'general service' in carbon-14 dating, due to begin shortly. The possibility of typifying certain pottery on a physical basis (that is, by making thin sections, etc.) is being examined, and a tentative suggestion was made about relating changes in the submicroscopic structure of wooden remains to the duration of burial under certain conditions.

Although the principles are in most cases fairly well understood, methods of preparing specimens (for example, for charcoal analysis) are sometimes imperfect, or there may be a lack of suitable comparative material in certain specific respects (for example, for matching rocks or bones); both here and in fields not so limited (for example, in counting pollen grains), the work is extremely tedious and time-consuming.

The majority of speakers thus reluctantly, but firmly, refused to accept investigations which were unlikely to help in solving some major problem. Even in the relatively simpler work of chemical analysis, identifying wood, and analysing mortars, isolated queries are discouraged unless submitted through some recognized institution. In the case of mortar analysis, as also with samples for carbon-14 and palæomagnetic examination, correct and careful sampling is essential. Where, as in the majority of cases, this aspect is less important, it is at least necessary to know the context accurately and reliably, because results can only be interpreted in relation to 'neutral' associated material. On the other hand, with problems involving soil and pollen analysis, or the corrosion of metals, it is absolutely vital for the investigator to be present during excavation in order to evaluate all aspects of the site from his point of view and to take his own samples. Archæological evidence is of great importance to research in botany, geophysics and metallic corrosion, and can be of great value to building research, soil science, human osteology, and the submicroscopic study of wood.

The suggestions made for improvement fall into four general groups. First, more workers and more (suitably selected) material for analysis and reference constitute major requirements. Several speakers stressed that such work, in general, is not appropriately recognized or paid, and consequently the

number of, say, geologists interested in archæological problems will always be very small. It would help if such small groups could meet regularly to discuss problems and progress. It was suggested that museum staff, in particular, should be approached with the view of interesting them more in this type of work. In Denmark, pollen analysts, petrologists and archæologists are successfully collaborating at the National Museum, and it was felt that the volume of such work in Britain would remain small until some similar scheme were put into operation.

It was further stressed that definite instructions should be issued to prevent the destruction or loss of valuable material (particularly botanical and osteological) and records (for example, of the preservation of buildings), and that these should be centrally stored and suitably catalogued; so that even if there should be no facilities for immediate examination, the material would be available later. Other suggestions included the preparation of sets of slides of petrological specimens from archæological finds, and organic-carbon assays (perhaps at university centres) to determine whether a sample is suitable for carbon-14 analysis. It is—as so very frequently in scientific work—most important to develop a battery of techniques for any one type of problem in order to obtain reliable results; thus no fewer than six methods were used in the recent investigation of the Piltdown mandible.

Secondly, it is important that archæologists should frame specific questions to accompany their material; this would considerably ease the investigators' burden, and serve to prevent friction and loss of time. In certain cases (for example, bones) excessive cleaning prior to dispatch from the site is undesirable.

Thirdly, it was obvious from all that had been said that the closest co-operation between archæologists and scientists at all stages is essential, not forgetting regular contact between, for example, the petrologists themselves who are engaged on archæological work.

Finally, this aspect becomes vital when (as in most cases) the problem has to be considered statistically. The examination of human bones can take on a wider significance only when its results can be related geographically. Only the archæologist can tell, in the last instance, which copper implements form a homogeneous series suitable for metallurgical analysis in attempting to trace the ores that have provided the metal; sometimes museum specimens of ores, selected on a different basis, may not include inferior material that might well have been used by early metal-workers.

In carbon-14 determinations, quite apart from the statistical errors due to equipment and method, structural differences between young and mature wood, and contamination both during and after burial may be expected to affect the results. A number of such 'rogues' have in fact been encountered, and single or even duplicate estimations may well be more misleading than helpful unless considered on a wider statistical basis. This calls for full and accurate publication of results, and the Council was urged to oppose firmly any unilateral 'editing' of scientific appendixes in archæological journals. It further points clearly to the need for planned research and, ultimately, for an Archæological Research Institute embracing all aspects and capable of both research and routine work. Concrete proposals for such a body, it was felt, should be worked out and submitted through the Council to the appropriate quarters as soon as possible.

In one of the concluding remarks the hope was expressed that, as a result of the conference which had thrown this aspect into relief, something might be done to make it easier for archæologists and scientists to understand one another; so that the archæologist could come to know the limitations of scientific techniques, and the scientist in his turn would be able to appreciate archæological requirements. The president, Dr. D. B. Harden, in thanking members of the conference on behalf of the Council, had no doubt that the latter would be glad to do what it could, particularly about 'vetting' material sent for expert examination, in order not to strain the limited resources available. He said that he and other archæologists present had been most encouraged by the support given to the conference; if an Archæological Research Institute still seemed a long way off, it was well worth while working towards it in the best possible way.

As reported in *Nature* of October 9, p. 677, a Scientific Research Committee for Archæology has now been formed by the Council. Further details may be obtained from the Assistant Secretary, Council for British Archæology, 10 Bolton Gardens, London, S.W.5.

L. Biek

PHYSICS OF CLOUDS AND PRECIPITATION

An international symposium was held at the Federal Institute of Technology, Zurich, during October 4–6, under the auspices of the Swiss Federal Commission for the Study of Hail Formation and Prevention, to discuss recent developments in the physics of clouds and precipitation and in the artificial modification of clouds. After the delegates had been welcomed by Prof. R. Sänger, president of the Commission, opening addresses were given by H. Dessens (France) on some theories of cloud nucleation submitted to experimental test, and by B. J. Mason (Great Britain) on the physics of natural precipitation processes.

M. Dessens described studies at the Pûy de Dome of the freezing of water droplets and the growth of ice crystals in the laboratory. The droplets, supported on spiders' threads, were suspended in a cold chamber on the stage of a microscope. Although large drops generally froze at higher temperatures than small ones, he obtained no clear-cut relation between drop size and freezing temperature because the freezing mechanism appeared to be propagated along the thread. However, large drops could be maintained at temperatures above −12° C. for many minutes without freezing.

The seeding of natural supercooled stratus clouds with silver iodide produced ice crystals if the temperature was below −4° C. and was often followed by precipitation and partial dissipation of the cloud. The seeding of similar clouds with 'dry ice' generally resulted in overseeding in the neighbourhood of the source, but precipitation and dissipation of the cloud did not follow. Large-scale seeding with silver iodide was carried out in the Pyrenees during 1951–53, but the effect on the rainfall was inconclusive. Clouds in this region tended to glaciate naturally if their summits were colder than −15° C.

Mr. Mason reviewed the present state of knowledge concerning the physical mechanisms which are

responsible for the release of precipitation from both shower- and layer-type clouds. Having traced recent theoretical developments, he analysed the information which has resulted from the exploration of clouds by aircraft and radar to illustrate the conditions under which rain might be produced either by the growth of ice crystals or by the coalescence of water droplets, and to point out how the cloud behaviour might be influenced by geographical and climatic conditions. The conclusion was that in middle latitudes the majority of rain from stratiform clouds is produced by the ice-crystal process and that the coalescence process is normally responsible for only drizzle or light rain. The radar echo from precipitating warm frontal clouds can be satisfactorily interpreted in terms of the growth and multiplication by splintering of ice crystals, their aggregation to form snowflakes, and the aggregation during melting of the latter to form raindrops. In the case of showers, however, it is considerably more difficult to decide which of the possible mechanisms may be dominant.

Calculations on the growth of precipitation elements in model clouds indicate the conditions under which showers may be released by coalescence (initiated, for example, by large hygroscopic nuclei), by the growth of ice particles, by the shedding of water drops from wet hailstones and by a process of raindrop multiplication due to disruption of large drops (raindrop chain reaction). In middle latitudes during the summer, and particularly over the sea, the coalescence process may forestall the ice particles in releasing precipitation even though the tops of the clouds may afterwards show glaciation. This may account for the fact that hail falls from only a small fraction of these clouds. The coalescence mechanism will be even more favoured in the deep, warm clouds of tropical regions where the conditions may often be suitable for the rapid multiplication of raindrops by a chain reaction.

In a session devoted to atmospheric aerosols, E. M. Fournier d'Albe described how the concentration and size distribution of large hygroscopic nuclei were measured at five ground-level stations in Pakistan. Near the coast the concentrations of particles with mass greater than 10^{-9} gm. were of order 100/m.^{3} but fell off rapidly inland. Although these particles were depleted during heavy rain, there was some evidence that hygroscopic nuclei were left behind when raindrops evaporated before reaching the ground. Dr. Fournier d'Albe thought that the main source of these particles was the sea and that they were responsible for releasing showers by initiating a chain reaction in the warm cumulus clouds of Pakistan.

O. Vittori (Italy) described microchemical tests for identifying microscopic and submicroscopic particles. The particles when caught on gelatine containing dissolved salts produce coloured rings of precipitate; particles of mass down to 10^{-15} gm. may be detected. This technique has been used to identify sulphate and chloride particles in the atmosphere and also various artificial aerosols such as silver nitrate. Some preliminary experiments for the physico-chemical detection of minute silver iodide particles were also described. It is not yet possible to determine accurately the masses of the particles by these methods.

Prof. C. G. Rossby (Stockholm) showed some results which had emerged from the chemical analysis of rainwater in Sweden, in particular the geographical distribution of various elements as measured over a two-year period. The total deposits of sodium and chlorine fell off very rapidly from west to east, much more rapidly than does the rainfall. The ratio chlorine/sodium by weight in the deposit showed a definite geographical pattern with values of 1·2 near the coast falling off to 0·6 well inland; these values have to be compared with a ratio of 1·8 for sea water. The distribution of calcium was fairly uniform over the country, but the ratios of calcium/sodium and potassium/sodium were generally much higher than those found in sea water.

In studying the supercooling of water drops supported on a metal plate, W. Rau (Germany) has found some evidence for the spectrum of freezing nuclei having maxima at −4° C., −11° C. and −19° C. Aqueous solutions show the same general spectrum of freezing nuclei but displaced to lower temperatures. Dr. Rau believes that precipitation from natural clouds tends to occur at rather well-defined temperatures and that this can be explained in terms of his spectra of freezing nuclei. He has measured the ice nucleus contents of air samples of different origin and has found polar air masses to contain many very efficient ice nuclei which are absent from subtropical air; he concludes that these nuclei were of maritime origin. He believes that the freezing of supercooled cloud droplets at −40° C. is brought about by freezing nuclei and that spontaneous nucleation occurs only at temperatures below −70° C. when cubic ice crystals are formed. He said that he had repeated his earlier experiments in view of criticisms that his apparatus may have been contaminated by alcohol, and he now reported that he can confirm his earlier results.

G. Soulage (France), having grown ice crystals in the atmosphere and allowed them to evaporate, found that their residues could act as centres for the formation of ice crystals at temperatures between −12° and −15° C. The particles had no particular crystalline shape, were partly insoluble and partly hygroscopic and acted as ice nuclei only after liquid water had condensed on them.

In a discussion on cloud physics, H. Byers (Chicago) described recent studies of cumulus clouds in Puerto Rico and in the middle of the United States with radar-equipped aircraft. The tropical clouds forming over the sea were relatively slow-growing and gave radar echoes when little more than 6,000 ft. deep, so that they were entirely below the 0° C. isotherm. Those forming over the island, however, showed much more rapid development, but did not precipitate until they attained considerably greater depths. The cloud droplets of tropical cumulus had a bimodal size distribution with maxima diameters of 10–15 μ and 30–50 μ, the latter no doubt being responsible for starting the coalescence process. In order to illustrate further the geographical differences of cloud populations, Prof. Byers also reviewed radar studies made of summer cumulus in New Mexico, which often reaches great heights without precipitating, and of thunderstorms in Ohio where the initial radar echo, in the majority of cases, is entirely below the 0° C. level, suggesting that the precipitation is initiated by coalescence.

F. H. Ludlam (London) described the observations made in central Sweden this summer as a part of a field-programme organized jointly by the Imperial College of Science and Technology, London, and the Institute of Meteorology, University of Stockholm. The behaviour of cumulus was studied with the aid of small aircraft, double theodolites, time-lapse

photography and radar. Particular attention was paid to the growth-rates of the clouds, their development during the day and the onset of precipitation. Careful studies of the glaciation of cloud summits indicated that this sometimes occurred at temperatures as high as −4° C. Showers sometimes fell from clouds little more than 1 km. deep.

The instrumentation of the aircraft of the British Meteorological Research Flight was described by R. J. Murgatroyd. A very rapid hot-wire thermometer was used to determine the thermal structure of the air below the bases of cumulus, while the airflow around the sides of the cloud was studied by following the relative motions of packets of 'window' with radar. Vertical currents inside clouds were measured with an integrating accelerometer and the liquid-water content with both a hot-wire instrument and a refrigerated icing disk. With the latter instrument, full adiabatic values of the water content were found in cold clouds. Measurements of the drop-size distribution in clouds by means of slides coated with either magnesium oxide or oil showed drops of radius 20–25 μ near the bases of stratocumulus clouds which were occasionally observed to produce rain if more than 4,000 ft. thick. Mr. Murgatroyd has evidence that in southern England summer showers are often released by coalescence and that even small cumulus often contains many drops of diameter 50 μ. Ice crystals appeared in detectable numbers only at temperatures below −12° C.

V. J. Schaefer (United States) outlined the cloud physics programme of the Munitalp Foundation, in particular the attempts to make a survey of cloud development at various sites in the United States with the help of voluntary observers using ciné cameras. He showed a number of colour films of clouds taken by members of the United States Forestry Service and of cloud systems which were associated with jet streams. M. Bossolasco (Milan) described some observations of precipitating clouds made at a mountain observatory and attempted to correlate the onset of precipitation with the temperature at screen level. G. Fea (Rome) reported on methods which were used to measure liquid-water content of clouds on Monte Cimone. G. Yamamoto (Japan), in his studies of the initial growth stage of ice crystal on nuclei of silver chloride and silver nitrate, has found crystals which are square rather than hexagonal prisms.

The main contribution on cloud seeding came from E. Bollay, who has conducted large-scale commercial trials in the United States, mainly with the object of increasing the snowpack in the lee of the Sierras. Silver iodide smoke was released on all occasions when clouds in the target area surpassed the −5° C. evel. The results were evaluated using a regression method in which past rainfall data were used to obtain a regression curve between the rainfall of the target and a control area, this being used to predict the rainfall to be expected naturally in the target area during the seeding period. Mr. Bollay estimates that in four successive years of operations in the Central Sierras they increased the snowpack by 27, 21, 7 and 22 per cent respectively. An independent assessment of three other operations by the Statistical Laboratory of the University of California suggests that in one case the rainfall showed a decrease, in another there was a considerable increase, the third being inconclusive.

In recognizing that there are certain factors which militate against commercial undertakings being able to carry out seeding experiments in the most scientifically acceptable form, Mr. Mason said that it is important for those interested in the purely scientific aspects of the problem to give considerable thought to the design and execution of a large-scale experiment. The results can be evaluated only on a statistical basis, and he indicated how an experiment might be designed using control and target areas, the decision to seed being made on the basis of a random choice. Such an experiment would probably take at least five years if rainfall increases of order 15 per cent were to be detected with reasonable confidence. Dr. Fournier d'Albe showed a film to illustrate how warm cumulus clouds were inoculated with salt particles dispersed from the ground in two areas in Pakistan. Particles of mass greater than 10^{-9} gm. were dispersed at a rate of 10 gm./sec., about half being carried aloft by the air. Although there was some preliminary indication that the rainfall was higher in the target regions than outside, a complete analysis of the results has not yet been made.

After three days of lectures and discussions, visits were arranged to the Institute for Snow and Avalanche Research on the Weissfluhjoch, Davos, and to the observatory of the Meteorologische Zentralanstalt at Locarno. These gave delegates an opportunity of seeing something of this beautiful country in which they were received with such friendliness and hospitality.

B. J. Mason

MARIE CURIE CELEBRATIONS IN WARSAW

THE twentieth anniversary of the death of Marie Sklodowska-Curie was celebrated at a special session of the Polish Academy of Sciences at Warsaw during October 6–8. This session was attended by Mrs. Irene Joliot-Curie, Madame Curie's daughter, and by specialists on various aspects of radioactivity from China, Czechoslovakia, France, Great Britain, Hungary, Norway and the U.S.S.R., as well as by a large number of Polish scientists who had gathered there from all parts of the country. Madame Curie's elder sister was a guest of honour, and in spite of her great age she was present at all the numerous functions of the session.

The first two days of the session were partly devoted to official speeches and surveys of the various physical and medical applications of radioactivity. Noteworthy was the speech by Mrs. Irene Joliot-Curie, in which she analysed her mother's work in a most vivid and personal way. Moreover, the participants attended the inauguration of a museum devoted to Madame Curie and installed in the newly rebuilt house where she was born in the so-called "New City" (which is actually an eighteenth-century extension of the Old Town). In this museum an extensive collection of documents and apparatus pertaining to Madame Curie is displayed in a most effective manner. The successive rooms are devoted to Madame Curie's childhood and family circle, her years of study in Paris, her great work in collaboration with her husband, her activities in promoting the medical use of radioactivity and her leadership of the Institut du Radium at Paris. The last rooms evoke the development of nuclear physics, which had its origin in the discovery of radioactivity, and lead the visitor to an impressive display of photo-

graphs illustrating on one hand the devastating use of nuclear energy in destroying cities and their inhabitants, and on the other the applications of nuclear energy for medical and industrial purposes (including a photograph of the first nuclear power station recently put into operation in the Soviet Union).

The last day of the session was entirely devoted to a more technical discussion of physical problems, and was held in the main lecture room of the Physical Institute. Among others, Prof. J. Rayski, of the University of Toruń (who is well known to nuclear physicists in Great Britain), presented a new interpretation of the various kinds of particles recently discovered in cosmic radiation. The Academy of Sciences and the State authorities also organized official receptions of the participants, who enjoyed, during the whole duration of their stay, the most cordial hospitality.

For the occasion the Academy of Sciences, which displays considerable activity in publishing scientific periodicals and excellent journals aiming at the popularizing of science, had issued a series of valuable books. These comprise Polish translations of Madame Curie's "Traité de Radioactivité", of Mrs. Irène Joliot-Curie's shorter text-book on nuclear physics, and also of Madame Curie's delightful short biography of her husband which originally appeared in French in 1924. Another book contains a collection of articles by various Polish scientists surveying Madame Curie's work and its implications, as well as a reprint of two articles written in Polish by Madame Curie. Last, but not least, a magnificent volume has been prepared containing a reprint in the original language (mostly French or Polish) of the complete works of Madame Curie. It is interesting to see to what extent Madame Curie was anxious to write popular articles or more technical surveys on the development of radioactivity in her native language. A bronze medal bearing the figure of Madame Curie was struck to commemorate the celebration.

The present writer had the opportunity of visiting in detail the Warsaw Physical Institute and of discussing questions of common interest with Polish physicists there. He was much impressed by the activity with which the newly reorganized Institute was teeming, and with the results already achieved in a surprisingly short time in trying circumstances. The Experimental Department of the Institute, under the direction of Prof. L. Sosnowski, pursues no less than four lines of investigation. Prof. Sosnowski himself is interested in problems of semiconductors; there is a section on nuclear physics (Prof. A. Soltan), a section on the study of cosmic rays by the emulsion technique (Prof. M. Danysz), and a section on optical and X-ray spectroscopy, which was set up by the late Prof. S. Pieńkowski, the creator of the Institute after the First World War. The Theoretical Physics Department occupies a new wing which was recently built in the space of a few months and which offers a group of very keen and active young theoreticians ideal conditions of work under the leadership of the two well-known theoretical physicists, Prof. L. Infeld and Prof. W. Rubinowicz. There are flourishing centres of research in physics at the other universities, which the writer had, however, no time to visit. The general impression from his brief contact with Polish physicists is that of a remarkably vigorous activity and growth, worthily upholding the brilliant traditions of Polish science.

L. Rosenfeld

SOCIAL IMPLICATIONS OF THE GENETICS OF MAN

In his presidential address to the Pacific Division of the American Association for the Advancement of Science, Prof. A. H. Sturtevant, of the California Institute of Technology, dealt with two matters. First, he emphasized the peculiar difficulties in the way of building up a sound body of knowledge on the formal genetics of man. These account for our gross ignorance of the part played by heredity, for example, in mental differences. Secondly, he considered the problems set by the genetical consequences of atom and hydrogen bombs.

Stressing that, for their effects on heredity, there is no lower level at which high-energy radiations are harmless, Dr. Sturtevant deprecated the statement by the Chairman of the Atomic Energy Commission that "... after every test ... there is a small increase in natural background radiation in some localities within the U.S.A. ... far below the levels which could be harmful in any way to human beings ...".

Dr. Sturtevant made the point that the risk is one to which the whole of mankind is already being subjected, and, if mankind survives for many generations, the bombs already exploded will ultimately and inevitably result in an increase in the harvest of defective individuals.

Few biologists will disagree with Dr. Sturtevant's criticism of the attitude exemplified above. The genetical consequences of a world atomic war would, clearly, be trivial compared with the immediate results. If mankind cannot avoid such a war there is not much point in speculating on the genetical consequences. But if it should be avoided, then a permanent increase, no matter how small, in radioactivity, be it due to industrial waste products or to the tests mentioned by Dr. Sturtevant, might become of tremendous importance. With present knowledge we are not even in a position to make a few intelligent guesses. It is to be regretted that Dr. Sturtevant, besides deprecating the light-hearted attitude towards biological problems mentioned above, did not also consider the consequences of the development of atomic energy for peaceful purposes. It seems to the reviewer that we are taking incalculable risks by building the factories without concentrating as much energy and money on the study of the long-term biological consequences of the atomic age.

G. Pontecorvo

UNITED NATIONS TECHNICAL ASSISTANCE BOARD

REPORT FOR 1953

The sixth report on the United Nations Expanded Programme of Technical Assistance for Economic Development*, submitted by the Technical Assistance Board to the Technical Assistance Committee of the Economic and Social Council, describes the progress

* United Nations Technical Assistance Committee. Sixth Report of the Technical Assistance Board. Economic and Social Council—Eighteenth Session—Supplement No. 4. Pp. vii+267. (New York: United Nations; London: H.M.S.O., 1954.) 2.50 dollars; 17*s.* 6*d.*; 10 Swiss francs.

of the programme during 1953, the third financial period. It also includes information on the approved programme for 1954 and some details on that proposed for 1955. Almost 200 out of the 267 pages of the report are occupied by the statements of the participating organizations and an analytical summary of the programmes for 1953–55 taken country by country. The general features of the Expanded Programme are discussed in an introduction which is illustrated by a series of diagrams and charts; and, in view of what has already been recently published in *Nature* (**173**, 50 and **174**, 1; 1954), it is unnecessary here to refer to more than a few points.

In the four years since the Programme began, the less-developed countries have re-examined their economic and social problems and have invited many thousands of experts from many lands to work with and for them. The technical skill and experience of many countries have been drawn upon to accelerate progress where it has lagged, and the report claims that in some measure the energies and initiative, the hopes and capacity for self-help of many peoples have been quickened. Nevertheless, the volume of technical assistance fell slightly, from 22,968,129 dollars in 1952 to 22,810,000 dollars, partly in consequence of a thorough review of the Programme, when pledges for 1953, totalling 22·4 million dollars, fell far below the cost of the technical assistance requested. The number of countries and territories receiving experts, however, increased from sixty-two to sixty-five, although fellowships were awarded to nationals of only eighty-two countries, compared with ninety-two in 1952, and sixty-seven, as compared with seventy-six, countries or territories acted as hosts to Fellows.

Attempting to distinguish features of the Programme on the basis of five years of operation, the report points out that only a small proportion of the funds is required to meet urgent priority requests: most technical assistance is designed to assist the less-developed countries in themselves solving chronic and age-long problems and represents only a fraction of sustained national effort required for appreciable and enduring results. The approved programme for 1954, for example, includes some eight hundred projects in each of which the average number of experts is about two throughout the year, and a hundred and fifteen projects which include only one fellowship each and no experts. Secondly, relatively little equipment is provided with the expert assistance: in 1953 only 10 per cent of obligations was for equipment and only about 6 per cent is planned for 1954. Thirdly, the Expanded Programme is not related directly to any source of capital supply.

Experience seems to show that a large proportion of the Programme in widely different fields must be devoted to training national personnel in the less-developed countries. Often these training facilities are linked with, or followed by, the award of fellowships to candidates recommended by the government concerned to enable them to follow a specified course at teaching institutions abroad. In many countries international experts have assisted governments in developing the institutional framework required for experimental work, pilot projects and development. It is also emphasized that the degree of underdevelopment and the requirements of various countries differ widely, and in most fields specific instruction and demonstration as to how to do things are taking the place of general advice as to what needs to be done.

During the year attempts were made for the first time to work out comprehensive technical assistance programmes at the country-level, and special attention to the possibilities of economy in the Board's field establishments led to a 24·5 per cent reduction in the estimated costs of these establishments for 1954. The holding of the Pledging Conference before the beginning of the Programme year also eased financial management in 1953, and the approval by the Technical Assistance Committee and the Economic and Social Council of proposals for the establishment of a reserve which might be utilized as a working capital and reserve fund should enable the Board to make advances to tide over time-lags between pledges and payment and to satisfy special currency requirements. Financial ceilings are now being imposed on obligations in order to regulate the rate of expenditure in relation to the rate of estimated collection. The Board is also re-examining the criteria and techniques to be used in judging the results of individual projects and the effectiveness of country programmes as a whole. In spite, however, of the improvement in financial management, the determined attack on administrative costs, the stronger co-operation between governments, agencies and the Board's representatives at the country-level and the improved co-ordination with other technical assistance programmes, much remains to be done to improve the operation of the Programme, to make more effective use of limited resources and to come to terms with the dimensions of the task for which the Expanded Programme was created. Once again it is clear that educational and economic advance should go side by side. Neither should dominate the other. This report should assist in formulating a clear conception of the principles involved in technical aid and what they require; and to overcome the difficulties encountered in obtaining a sufficient supply of experts and retaining their services, it may well prove necessary to form an international cadre with continuous and guaranteed agreed terms of service operating for something in the nature of a World Development Authority.

FISH CULTURE IN INDONESIA

THERE has recently been published by the Food and Agriculture Organization (F.A.O.) a highly important report* on fish culture in Indonesia. This report comprises a selection of the papers delivered and discussed at a seminar on brackish- and freshwater fish culture, held at Djakarta during April 11–May 23, 1951, under the ægis of the Indo-Pacific Fisheries Council.

It is now generally recognized that the fish resources of the sea, vast though they be, are not limitless, nor are they uniformly distributed throughout the seas and oceans of the world. In many highly populated regions of the earth, especially within the tropics, the marine fisheries are as yet poorly developed and their yields make inadequate contributions to the needs of the inhabitants. In consequence, great effort is being made in many such regions—much of it under the inspiration and guidance of the Food and Agriculture Organization—to increase the yield of sea foods.

* Fish Culture in Indonesia. G. L. Kesteven, General Editor. Indo-Pacific Fisheries Council (F.A.O.) Special Publication No. 2. I.P.F.C. Secretariat, F.A.O. (Regional Office for Asia and the Far East, Bangkok, 1953.) n.p.

This can be done only by streamlining and improving fishing methods and intensifying fishing effort. It is already clear, however, that in many places the ultimate yields from the sea's natural resources can never fully meet the unsatisfied demands for animal proteins; and no means have yet been found of adding appreciably to the sea's productivity by culture methods. Fish farming is not feasible in the sea; but in brackish lagoons and fresh inland waters it is both possible and profitable and has long been practised in various parts of the world.

Great effort to improve and extend the practice of fish culture in fresh and brackish waters is therefore now being made, especially in the Indo-Pacific region. This volume on fish culture in Indonesia is thus a most valuable document. It opens with a general description of the inland fisheries of Indonesia followed by reports on: (1) the anatomy and physiology of the milkfish or bandeng, *Chanos chanos*; (2) the capture and transportation of its fry for stocking purposes; (3) the breeding of carp, *Cyprinus carpio*; (4) the plankton populations of brackish-water ponds; (5) the occurrences of *Anopheles* larvæ in rice fields during combined cultivation of rice and fish. There are also brief notes on many other allied problems.

Practical fish culturists and all others interested in improving and extending the science and art of fish culture will be grateful to the Food and Agriculture Organization for providing in this publication such a rich fund of useful information.

The Organization has also published a second (revised) edition of its valuable List of Scientific and other Periodicals published in the Indo-Pacific Area*.

G. A. Steven

* List of Scientific and other Periodicals published in the Indo-Pacific Area. 2nd edition (revised). Indo-Pacific Fisheries Council, I.P.F.C. Secretariat, F.A.O. (Regional Office for Asia and the Far East, Bangkok, 1953.) n.p.

PARTICIPATION OF COENZYME A IN THE OXIDATION OF FAT*

By Prof. F. LYNEN

Biochemical Department, University Chemical Laboratory, Munich

RESEARCH in recent years has greatly increased our understanding of the pathways involved in fat metabolism and has confirmed the classical β-oxidation theory of Knoop[1] as the chief process by which fatty acids are oxidized. Fatty acid chains undergoing this process are cleaved into C_2-fragments, until recently known as 'active acetate', as their true nature was a mystery. The discovery of coenzyme A by Lipmann[2] was followed by that of the 'energy-rich' acylmercaptans or thioesters[3]. This led to the identification, three years ago, of 'active acetate' as the thioester formed from coenzyme A and acetic acid (acetyl-coenzyme A)[4]. Knowing this, it was possible to formulate a provisional scheme for the oxidation and synthesis of fatty acids[4-6]. The essentials of this scheme were soon confirmed, owing to the rapidity with which the enzyme systems involved were isolated and studied by several laboratories[7-10], including my own in Munich[11].

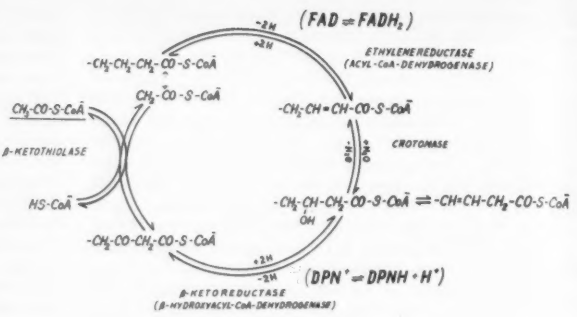


Fig. 1. Fatty acid cycle

This scheme (Fig. 1) represents a 'fatty acid cycle'. The synthesis of fatty acids is achieved by a repetition of four consecutive steps, catalysed by four new enzymes, which hand to each other substrates of different chain-length. (Recent experiments show that there exist two ketothiolases[7] and two ethylene reductases[8], each specific to substrates with certain chain-lengths.) I have named these enzymes according to the direction of their equilibria under physiological conditions. The four steps are as follows: (1) one molecule of acetyl-coenzyme A condenses with another, giving acetoacetyl-coenzyme A; (2) acetoacetyl-coenzyme A is reduced to β-hydroxybutyryl-coenzyme A in the presence of reduced diphosphopyridine nucleotide; (3) β-hydroxybutyryl-coenzyme A undergoes dehydration to crotonyl-coenzyme A; (4) crotonyl-coenzyme A is reduced to butyryl-coenzyme A in the presence of reduced flavine.

In these four steps the carbon chain of the original acetyl-coenzyme A is extended by two carbon atoms. An additional acetyl-coenzyme A and four additional hydrogen atoms are required. The butyryl-coenzyme A so formed can re-enter the cycle through condensation with another molecule of acetyl-coenzyme A to give ketocaproyl-coenzyme A, afterwards undergoing reduction to caproyl-coenzyme A. The repetition of the cycle eight times in a spiralwise manner will produce stearyl-coenzyme A (C_{18}). Fatty acid coenzyme A derivatives formed in the 'spiral' can transfer their acyl groups to α-glycerophosphate, forming diacyl phosphatidic acids[12], possible precursors of the phosphatides and true fats. The transferring enzyme concerned is highly specific for fatty acid chains of 16, 17 or 18 carbon atoms, which may account for

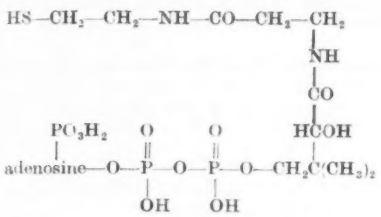
Table 1. R—CO—S—CH_2—CH_2—NH—CO—CH_2

Acyl (R—CO)	Melting point	Investigator
CH_3—CO—	30°	R. Kuhn and G. Quadbeck (ref. 15a), G. Vogelmann
CH_3—CH_2—CH_2—CO—	28°	W. Seubert
CH_3—CH=CH—CO—	62–63°	W. Seubert
CH_3—CH(OH)—CH_2—CO—	fl.	T. Wieland and A. Bernhard, K. Decker
CH_3—C(=O)—CH_2—CO—	60°	G. Vogelmann and L. Wessely
CH_3—$(CH_2)_2$—CO—	22°	W. Seubert
CH_3—$(CH_2)_4$—CO—	45–46°	W. Seubert
CH_3—$(CH_2)_6$—CO—	60°	W. Seubert

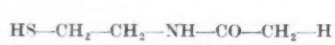
* Summary of a lecture given on March 8 at University College, London. The experimental work reported was aided by grants from the Deutsche Forschungsgemeinschaft, Bad Godesberg, and the Rockefeller Foundation, New York.

the preponderance of palmityl and stearyl glycerides in Nature. By reversing the 'spiral' the complete degradation of a fatty acid chain into C_2-fragments can occur, provided that the fatty acid is first activated by combination with coenzyme A.

The study of these four new enzymes in our laboratory in Munich has been based on the application of the elegant optical methods of Warburg[13], and on the wide use of model derivatives of coenzyme A—the derivatives of N-acetyl cysteamine, an analogue of coenzyme A.



Coenzyme A

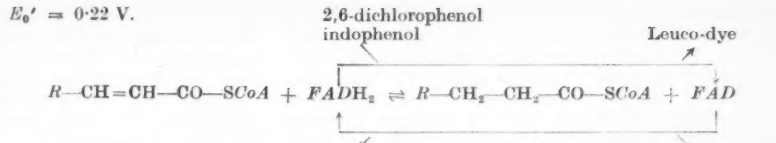


N-Acetyl cysteamine

These model compounds were first prepared by us with the object of obtaining information about the chemical properties of the predicted intermediaries of the fatty acid cycle (Table 1). They also proved to be of great value in the study of enzyme reactions. Not only are they inexpensive and readily available (unlike coenzyme A and its derivatives), but they can also be prepared in the laboratory as analytically pure compounds. Some of them possess, in common with the coenzyme A derivatives, strong absorption bands in the ultra-violet. The S-crotonyl and S-acetoacetyl derivatives possess absorption bands at 263 mμ and 303 mμ (pH > 8, enolic form) respectively, and the thioesters of the saturated fatty acids and the β-hydroxyacids have a band at 233 mμ [14]. The model compounds must be used at higher concentrations than the corresponding coenzyme A derivatives, as the enzymes concerned have a lower affinity for them. The models possess the correct configuration of atoms next to the active group but lack the anchor, perhaps provided by the phosphate groups of coenzyme A, for their firm attachment to the enzyme. In this respect the enzymes of the fatty acid cycle may resemble the triose phosphate dehydrogenase[13,15].

Ethylene reductase is a flavoprotein enzyme with flavadenine dinucleotide as prosthetic group, an observation made independently in Munich[16] and in Madison[17,17a]. It catalyses the oxido-reduction between saturated fatty acid derivatives of coenzyme A and flavine, and can also react with the model compounds. This reaction may be followed spectrophotometrically by observing either the bleaching of 2,6-dichlorophenol indophenol by the saturated fatty acid derivatives, or the regeneration of colour from leucosafranin *T* by the S-crotonyl derivatives.

$E_0' = 0{\cdot}22$ V.

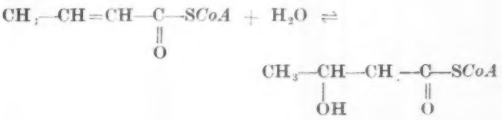


$E_0' = -0{\cdot}29$ V.

(*FAD* = flavine adenine dinucleotide ; $FADH_2$ = reduced *FAD*)

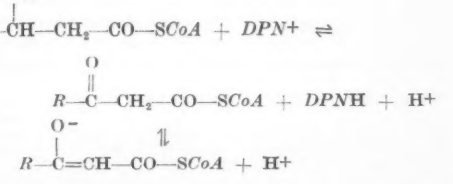
The enzyme was purified four hundred times from sheep liver extract, using the second reaction for the assay system[16]. The enzyme has the same affinity for model as for natural compounds, but, in order to achieve the same velocity at identical substrate concentrations, three times more enzyme is needed with the model compound than is needed with the natural one. This suggests that the transfer of hydrogen from the natural substrate to flavine is three times more rapid than the transfer from the model compound. The rate of oxidation of the model fatty acid derivatives increases with chain-length. We have evidence that our purified ethylene reductase is different from the 'acyl-coenzyme A dehydrogenase', isolated in Madison[17].

Crotonase catalyses the reversible hydration of the thioesters of the unsaturated acids to the corresponding β-hydroxyacids[18,19].



This reaction may be followed by measuring changes in the absorption band of S-crotonyl derivatives at 263 mμ[7]. The extinction coefficient of this band is sufficiently high to prevent significant interference by the adenine band of coenzyme A at 260 mμ. Crotonase can remove water from β-hydroxybutyryl-coenzyme A to give vinyl-acetyl-coenzyme A[18,19], an unsaturated fatty acid with the double bond between carbons 3 and 4. The incorporation of such a fatty acid into a chain undergoing synthesis in the 'spiral' could explain the distribution of double bonds, in a number of naturally occurring unsaturated fatty acids (for example, linolenic, $C_{9:10}$, $C_{15:16}$, arachidonic, $C_{8:6}$, $C_{11:12}$).

β-Ketoreductase catalyses the reduction of the S-acetoacetyl derivatives of coenzyme A and N-acetyl cysteamine to the corresponding β-hydroxyacid derivatives, using reduced diphosphopyridine nucleotide (*DPN*H) as hydrogen donor[20,20a].



Of the two enantiomorphs of the β-hydroxyacid, only the D-compound takes part in the reaction[10]. This may be followed by using S-acetoacetyl-N-acetyl cysteamine as the substrate, and measuring the disappearance of reduced diphosphopyridine nucleotide.

Considerable purification of the enzyme from sheep liver was obtained, using this assay system[20]. The affinity of the enzyme for its natural substrate is one hundred times greater than its affinity for the model compound. At physiological *p*H the equilibrium of the reaction lies towards oxidized diphosphopyridine nucleotide and β-hydroxyacyl-coenzyme A, but shifts towards the S-acetoacetyl compound with rising *p*H. Above *p*H 8·5 the acetoacetylmercaptan dissociates to give the enolate ion. The latter effect can be used in the preparation of S-acetoacetyl or higher β-ketoacyl derivatives of coenzyme A. This was first done in our laboratory in Munich[20] and later elaborated by Beinert in Madison[21]. Various tissues have been examined for the presence of the enzyme. Of all the organs tested, the brain was found to contain very little (Fig. 2), which agrees with the well-known fact that this organ can metabolize carbohydrate but not fat.

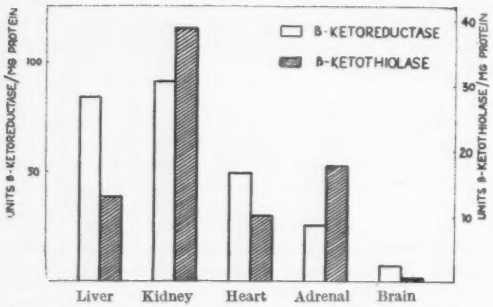


Fig. 2. Occurrence of β-keto reductase and β-keto thiolase in various sheep tissue-extracts

(1) $CH_3—CO—CH_2—CO—SR + HSCoA \xrightarrow{\beta\text{-ketothiolase}} CH_3—CO—SCoA + CH_3—CO—SR$

(2) $CH_3—CO—SCoA + H_2N\langle\rangle NO_2 \xrightarrow{\text{acetokinase}} CH_3—CO—NH\langle\rangle NO_2 + HSCoA.$

cannot be followed at 303 mμ. This difficulty can be overcome by coupling the enzyme with the acetokinase for aromatic amines from pigeon liver. The acetyl-coenzyme A formed by the thiolytic cleavage acetylates *p*-nitroaniline, giving an almost colourless compound[23], and the overall reaction can be followed optically[23].

Acetoacetyl-coenzyme A and acetoacetyl-glutathione will also react in this system, showing the wide range of the β-ketothiolase, the only enzyme so far known which will react with the S-acyl derivatives of glutathione.

We have come to the conclusion that the enzyme participates in the reaction, in the following stoichiometric manner, by means of a thio group, which is essential to its activity[14].

(1) Enzyme SH + $CoAS—CO—CH_2—CO—CH_3 \rightleftharpoons$ enzyme S—CO—CH_3 + $CoAS—CO—CH_3$.

(2) Enzyme S—CO—CH_3 + $CoASH \rightleftharpoons$ enzyme SH + $CoAS—CO—CH_3$.

The distribution of the enzyme in certain tissues is shown in Fig. 2. The great accumulation of the enzyme in the suprarenal gland suggests that it might participate in the synthesis of steroids from acetyl groups, via squalene[24]. We suggested more than two years ago that a 'building block' suitable for such biosyntheses, and containing five carbon atoms in an isoprene structure, could be produced in a fashion analogous to the *in vivo* synthesis and transformation of citrate[25].

(1) $2\,CH_3—CO—SCoA \xrightarrow{\beta\text{-ketothiolase}} CH_3—CO—CH_2—CO—SCoA + HSCoA.$

(2) $CH_3—CO—CH_2—CO—SCoA + CH_3—CO—SCoA \xrightarrow[\text{enzyme}]{\text{condensing}} CH_3—\underset{\displaystyle CH_2—COOH}{\overset{\displaystyle OH}{C}}—CH_2—CO—SCoA + HSCoA$

(3) $CH_3—\underset{\displaystyle CH_2—COOH}{\overset{\displaystyle OH}{C}}—CH_2—CO—SCoA \xrightarrow{-H_2O} CH_3—\underset{\displaystyle CH_2—COOH}{C}=CH—CO—SCoA \xrightarrow{-CO_2} CH_3—\underset{\displaystyle CH_3}{C}=CH—CO—SCoA$ (ref. 26)

β-*Ketothiolase* catalyses the reversible cleavage of acetoacetyl-coenzyme A into two molecules of acetyl-coenzyme A[7,21]. The equilibrium of the reaction under physiological conditions lies towards the thiolytic cleavage, one thousand molecules of acetyl-coenzyme A being in equilibrium with about five molecules each of acetoacetyl- and free coenzyme A.

$$R—\overset{\displaystyle O}{\overset{\|}{C}}—CH_2—CO—SCoA + HSCoA \rightleftharpoons R—CO—SCoA + CH_3—CO—SCoA.$$

The reaction may be followed by observing changes in the absorption band of acetoacetyl-coenzyme A at 303 mμ[14]. The model compound, S-acetoacetyl-N-acetyl cysteamine, can replace the natural substrate, but at such high concentrations that the reaction

Activation of fatty acids. In the fatty acid cycle fatty acids are not metabolized in the free form, and prior to oxidation must undergo activation by combination with the thio group of coenzyme A[7,26a,30]. Three enzymes are known which catalyse this reaction. One, which has received the most intensive study, activates acetate and propionate[7,26a,30]; another activates fatty acids, unsaturated fatty acids and β-hydroxy-acids of chain-length C_4–C_{11}[27]; and a third activates higher fatty acids up to C_{22}[28]. The activation needs energy from adenosine triphosphate[29], which was shown by Lipmann and his co-workers to split into adenosine monophosphate and pyrophosphate during the activation of acetate[30]. The recent collaboration of our team with Lipmann's elucidated the mechanism of acetate activation[31]. This seems to require the stoichiometric participation of a group (*X*) on the enzyme in a three-step reaction:

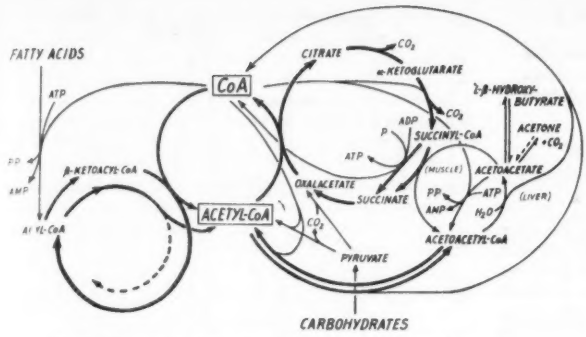


Fig. 3. Interaction of the fatty acid cycle and the citric acid cycle

(1) Enzyme X + $Ad—P\sim PP$ ⇌ enzyme $X\sim P—Ad$ + PP.

(2) Enzyme $X\sim P—Ad$ + $HSCoA$ ⇌ enzyme $X\sim SCoA$ + $Ad—P$.

(3) Enzyme $X\sim SCoA$ + CH_3COOH ⇌ enzyme X + $CH_2CO\sim SCoA$.

(Ad = adenosine, $Ad—P$ = adenosine monophosphate, PP = pyrophosphate).

It has been known for many years that the metabolism of fat is closely integrated with that of carbohydrate, but only now is it possible to have a clear picture of this integration at the enzymatic level (Fig. 3). For the synthesis of fat the fatty acid cycle is dependent upon the supply of acetyl-coenzyme A and reduced diphosphopyridine nucleotide, derived from the breakdown of carbohydrate. A high concentration of these substrates must be maintained, and the concentration of free coenzyme A kept low, if the equilibria of the β-ketothiolase and the β-ketoreductase are to be shifted in the direction of synthesis. In the living organism the supply of these two substrates is crucial in deciding if fat is to be synthesized or oxidized. In diabetes, where the metabolism of carbohydrate is depressed, the stationary concentration of reduced diphosphopyridine nucleotide in the liver is lowered[22] and the synthesis of fatty acids restricted.

The acetyl-coenzyme A derived from the oxidation of fatty acids passes into the citric acid cycle by condensation with oxaloacetate, to be oxidized to carbon dioxide and water. The level of fatty acid oxidation is therefore determined by the rate at which oxaloacetate becomes available. If this rate falls off, through the depression of carbohydrate metabolism, as in diabetes, then acetyl-coenzyme A cannot be metabolized completely. Acetoacetyl-coenzyme A accumulates and gives rise to the 'ketone bodies' of the blood by being hydrolysed by a deacylase, found only in liver, to give free acetoacetate. Acetoacetate may be reduced or decarboxylated to β-hydroxybutyrate or acetone. In normal animals acetoacetate can be used to provide energy[23], for once activated with coenzyme A it will give rise to acetyl-coenzyme A, which enters the citric acid cycle. Two such activating mechanisms are known. Stern[24] and Green[25] discovered independently an enzyme which exchanges acetoacetate with the succinate of succinyl-coenzyme A (arising from the citric acid cycle) to give acetoacetyl-coenzyme A and free succinate. There is also an enzyme, found mainly in kidney[8], which catalyses the direct activation of acetoacetate with coenzyme A and adenosine triphosphate. The level of the blood acetone bodies will be controlled by the inter-relationships of such systems producing and utilizing acetoacetate.

The smooth integration of fat and carbohydrate metabolism depends upon a steady turnover of coenzyme A. Free coenzyme A is acylated in the activating and thiolysing steps, and is liberated from the acylated form by condensation reactions involving acetyl-coenzyme A. This turnover explains why coenzyme A does not appear on the balance equation of β-oxidation, and provides a beautiful example of the catalytic functioning of coenzyme A in the living organism.

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LETTERS TO THE EDITORS

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Ion-Exchange Chromatography of Guanidino Amino-acids from Synthetically Modified Gelatin

Elution chromatography of amino-acids on columns of 'Dowex 50' by the method of Moore and Stein[1] has proved a versatile technique for the analysis of biological materials[2–4]. Application of the method to chemically modified proteins has received little attention. The present investigation, in which it has been used to separate two amino-acids, considered to be homoarginine[5] and hydroxyhomoarginine, from hydrolysates of a guanidated gelatin, illustrates its power in this connexion.

The parent gelatin (17·9 per cent nitrogen), prepared from cattle hide after prolonged treatment with lime[6], was guanidated[7] by treatment with O-methyl isourea at *p*H 10–12. The guanidino gelatin (18·7 per cent nitrogen) had an isoelectric point, determined by the method of Janus, Kenchington and Ward[8], at *p*H 4·91, identical with that of the original gelatin, whereas its titration curve showed almost complete removal of ε-amino-groups. This would suggest conversion of the ε-amino-groups to guanidino-groups which, if complete, would give rise to an increase in total nitrogen of 0·87 per cent.

The gelatin and the guanidated product were de-ionized[3] with mixed-bed ion-exchange resins to remove all small ions and hydrolysed in sealed tubes with 6 *N* hydrochloric acid at 100° for 24 hr. The hydrolysates were chromatographed on 15 cm. × 0·9 cm. columns of 'Dowex 50' and eluted with 0·1 *M* sodium citrate, *p*H 4·95 for the first 25 ml. The elution curve of the gelatin (Fig. 1,*a*), in which the actual optical density of the test solution from each fraction is plotted against eluant volume, showed peaks corresponding to hydroxylysine, histidine, ornithine, lysine, ammonia and arginine. The asymmetry of the hydroxylysine peak was attributed to partial separation of the diastereoisomers[9]. The small ornithine peak partially merged into the leading edge of the lysine peak. This gelatin contained an abnormally large proportion of ornithine, formed by alkaline decomposition of guanidino-groups during manufacture. Collagen and acid-process[6] gelatins have been shown to contain no ornithine[10], whereas gelatins prepared after short lime treatments have small amounts.

The chromatogram of the guanidino gelatin (Fig. 1,*b*) showed almost complete absence of hydroxylysine, ornithine and lysine, increased arginine and the appearance of two new peaks. The first of these peaks, emerging between ammonia and arginine, was attributed to hydroxyhomoarginine, formed by guanidation of hydroxylysine. The peak emerging after arginine was considered to be homoarginine derived from lysine. The high and variable blank, in the region of the ammonia peak, due to emergence of ammonia accumulated from the buffer solutions, necessitated the removal of ammonia from alternate fractions to permit accurate estimation of hydroxyhomoarginine. The 1-ml. fractions were brought to *p*H 11·5 by addition of 0·051 ml. of *N* sodium hydroxide and ammonia was removed by evacuation at 15 mm. pressure for 4 hr. The fractions were then brought

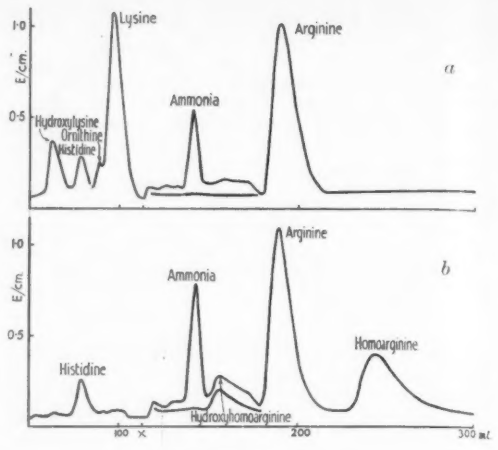

Fig. 1. Elution curve from 15 cm. × 0·9 cm. columns of 'Dowex 50' of hydrolysates of (*a*) 11·07 mgm. of gelatin, and (*b*) 11·07 mgm. of guanidated gelatin. The lower curve for fractions 120–180 indicates values obtained after removal of ammonia. The eluant buffer was changed from *p*H 6·75, 0·1 *M* sodium phosphate to *p*H 6·50, 0·2 *M* sodium citrate at the point marked *X* (113 ml.)

to *p*H 5·0 by addition of 0·097 ml. of 2 *N* hydrochloric acid before addition of ninhydrin reagent[11].

The contents of basic amino-acids of the gelatins are shown in Table 1. The 'colour yields'[11] of homoarginine and hydroxyhomoarginine were assumed to be the same as for arginine. The sum of the hydroxyhomoarginine and residual hydroxylysine of the guanidino gelatin is rather less than the original hydroxylysine content. This may be due to errors in the integration of the small hydroxylysine peak, arising from uncertainty in the position of the base line. Rather lower hydroxylysine values have been obtained with other gelatins[10]. The increase in the arginine content exceeds what would be expected from guanidation of ornithine. Errors in the estimation of ornithine are substantial, although these do not affect the combined figure for lysine and ornithine. The sum of the homoarginine, the increase in arginine and the residual lysine of the guanidated gelatin (35·0 residues per 10^5) agrees with the original total of ornithine and lysine (33·9 per 10^5), confirming that the discrepancies arose from the analysis of the overlapping peaks.

Arginine, homoarginine and hydroxyhomoarginine all give rise to asymmetrical peaks, each having a gradually falling trailing edge which appears to be

Table 1. Content of Basic Amino-acid Residues and Amide Nitrogen of a Limed Hide Gelatin, before and after Guanidation

	No. of residues per 10^5 molecular weight of parent gelatin* (that is, 1,105 total residues)	
	Gelatin	Guanidino gelatine
Hydroxylysine	7·7	0·3
Hydroxyhomoarginine	0·0	6·7
Ornithine	2·7	0·0
Lysine	31·2	1·4
Homoarginine	0·0	28·0
Arginine	47·6	53·2
Histidine	5·6	5·3
Amide groups†	6·0	11·4

* 1 gm. of gelatin gives rise to 1·017 gm. of fully guanidated gelatin.
† Corrected for ammonia formed by decomposition of serine and threonine during hydrolysis.

characteristic of the guanidino-group. The sharp separation of arginine and homoarginine, each of which contains the same three ionizable groups and which differ only by one carbon atom in chain-length, illustrates the high resolution of basic amino-acids on 15-cm. columns of 'Dowex 50', eluted with nearly neutral buffers. Substitution of a hydroxy-group in homoarginine has the effect of causing an earlier emergence of the hydroxy amino-acid, a result also shown by the pairs lysine and hydroxylysine and alanine and serine.

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Colour Reaction for Deoxyribose Compounds

The two most commonly used methods for detecting deoxyribose compounds are the diphenylamine reaction[1] and the cysteine–sulphuric acid method[2,3], both originally discovered by Dische. Overend and Stacey[4] have made the most recent survey of the usefulness of these methods. Both methods suffer from the same fault, that neither measures pyrimidine-bound deoxyribose quantitatively. Brody[5] has used the cysteine–sulphuric acid method under conditions of precise temperature control for the quantitative determination of deoxyribose nucleic acid. It was not determined whether or not the pyrimidine-bound deoxyribose compounds were as chromogenic as the purine-bound sugars. The observations presented here show that the method can be employed for a variety of compounds containing deoxyribose.

The only change from the description by Brody was to decrease the final volume from 5·55 ml. to 3·33 ml., and the amounts of reagents used were reduced accordingly. The intensity of colour that developed was determined in the Beckman spectrophotometer at 474 mμ. Assuming that each mole of deoxyribose is quantitatively converted to the chromogen, Table 1 shows the apparent molar extinction coefficient of this chromogen as derived from tests with a variety of compounds containing deoxyribose. Within experimental error, the observed molar extinction coefficient is the same. It appears, therefore, that pyrimidine-bound deoxyribose reacts as well, quantitatively, as purine-bound deoxyribose. One can therefore use this method to determine the total deoxyribose content of a given sample. One can also determine the amount of purine-bound and pyrimidine-bound deoxyribose in any sample by a combination of the diphenylamine reaction and the cysteine–sulphuric acid method as described by Brody.

Table 1. Reaction of Deoxyribose Compounds in the Cysteine–Sulphuric Acid Method.

The test was carried out under the conditions described in the text. 50 μgm. of each substance was used, and the apparent molar extinction coefficient calculated from the value obtained

Substance	Apparent molar extinction coefficient of the chromogen ($\times 10^4$)
Adenine deoxyriboside	1·6
Thymidine	1·5
Cytosine deoxyriboside	1·3
Deoxyguanylic acid	1·4
Deoxyadenylic acid	1·3
Thymidylic acid	1·4
Thymidine diphosphate*	1·5
Deoxycytidylic acid	1·5
Thymus deoxyribonucleic acid†	1·4

* A commercial sample obtained from the California Foundation for Biochemical Research, Los Angeles, Calif.
† A commercial sample obtained from General Biochemicals, Inc., Chagrin Falls, Ohio. The apparent molar extinction coefficient was calculated on the basis of the composition of the deoxyribonucleic acid being a statistical tetranucleotide.

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Correlation between Endogenous Auxin and its Destruction *in vivo* by 2 : 4-Dichlorophenoxyacetic Acid in Plants

Several investigators have recently pointed out the accelerating effect of 2 : 4-dichlorophenoxyacetic acid (2,4-D) on the destruction of auxin in dicotyledonous plants[1–3]. In addition, one group[3] has revealed that the opposite effect prevails in oat coleoptile sections, that is, 2,4-D effects a prevention or 'sparing action' of the previously reported destruction of indolylacetic acid in oat coleoptiles[4].

Experiments *in vitro* using etiolated oat coleoptile, pea epicotyl and sunflower hypocotyl sections (3 mm.), have shown that these two phenomena do indeed occur under similarly controlled conditions. Table 1 indicates that 2,4-D in increasing concentrations causes a continuously retarded destruction of added indolylacetic acid (50 mgm./l.) with oat sections. The opposite is shown for the pea and sunflower sections.

Next, intact plants grown in 'Terralite' were sprayed *in vivo* in the greenhouse and in the *Avena* dark room with 1,000 p.p.m. (4×10^{-3} *M* of sodium salt) of 2,4-D and allowed to stand 12–48 hr. (or longer for beans). Plant parts, exclusive of leaves, were extracted in the cold room (0–2° C.) with two successive portions of wet, peroxide-free ether over a 16-hr. period. The extracts were then made up in the usual manner for use in the Went *Avena* assay.

The results, as shown in Table 2, indicate that there is fairly good correlation between the previously cited effect of 2,4-D on auxin destruction (Table 1)

Table 1. Time in hours to cause complete destruction of indolylacetic acid (50 mgm./l.) in 30 sections of 3 mm. length (total volume of medium 12 c.c.). Phosphate buffer, *p*H 6·5. Continuous shaking at 110 oscillations per minute at 30° C.

Species	Concentration of 2,4-D (p.p.m.) 0	250	500	1,000
Oat	4·5	5·0	6·0	9·0
Pea	6·0	4·5	4·5	6·0*
Sunflower	4·0	3·5	3·25	4·0*

* Destruction possibly inhibited by disorganization of the tissues in the sections due to high concentration of 2,4-D.

Table 2. Endogenous auxin in plants treated with 2,4-D at 1,000 p.p.m. (after 48 hr.). Tested by *Avena* assay of Went

Species	Wet wt. (gm.)	Curvature of *Avena* coleoptiles Untreated	Treated	Standard IAA 25 r./l.
Oa *	2·0	7·2	8·2	11·7
Sunflower	5·0	13·8†	7·8†	9·7
Pea	5·0	9·0	5·8	10·0
Bean	2·3	73·0	16·4‡	av. 10·5

* Average of four separate runs made at widely different times.
† One run out of three gave: untreated, 13·5°; treated, 3·8°.
‡ These plants were treated with 10, 100 and 1,000 p.p.m. 2,4-D; results: 52°, 18°, 16°, respectively.

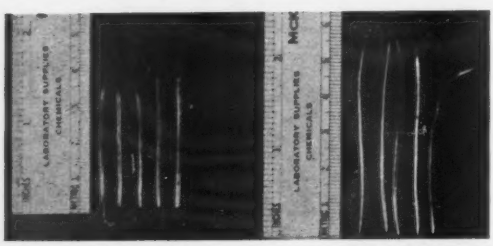
and the amount of endogenous auxin remaining in the plant sections. It is obvious that the dicotyledons are definitely influenced by 2,4-D either in their auxin synthesis or in its destruction, since the levels of auxin in the treated plants are significantly lower than in the untreated ones. Conversely, the *Avena* sections show the opposite trend. Weintraub[5] reports that endogenous auxin is influenced by 2,4-D.

It was noticed that when the *Avena* coleoptiles were sprayed with 2,4-D, the coleoptiles were not only bent or distorted slightly, but that they were appreciably taller than the untreated plants. Fig. 1 illustrates this phenomenon. Untreated plants, 4½ days old, averaged 40 mm. in coleoptile length, whereas the treated plants averaged 60 mm. in length. It is also obvious in these plants that the first leaf is well below the tip of the coleoptile in the treated plants, indicating the more rapid growth of the coleoptiles.

More significantly, the extract of the treated plants gave $3{\cdot}5 \pm 0{\cdot}9°$ curvature for twelve plants by the *Avena* assay, whereas the untreated gave $1{\cdot}5 \pm 0{\cdot}6°$ (standard error). These results, while not in the more valid range of curvature ($> 5°$), seem to indicate a trend towards a 2,4-D sparing action of endogenous auxin.

It appears that the greater elongation of the treated coleoptiles might be related more to a sparing action of native auxin by 2,4-D than to the direct influence of the latter on cellular elongation. Sufficient evidence exists that this could be the possible explanation, just as it appears to be the cause for the continued acceleration of respiration in the coleoptile sections under the influence of added indolylacetic acid and 2,4-D[3]. Experiments are under way, using decapitated and non-decapitated coleoptiles, in an attempt to elucidate whether the increased growth is a result of the 2,4-D or native auxin.

Thus, it is possible that these observations might bring about a new interpretation of some of the previously unexplained results involving the use of 2,4-D on plants.



Untreated — Treated with 1,000 p.p.m. 2,4-D

Fig. 1. *Avena* coleoptiles (sample of five out of *c.* 200) untreated and treated with 2,4-D, the latter after 36 hr. exposure to 1,000 p.p.m. All plants grown in *Avena* 'dark' room

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Some Cytological Observations on the Delayed Effect of Mustard Gas

In the course of a quantitative study of re-arrangements induced by mustard gas in *Drosophila melanogaster*[1], 757 progeny of treated males have so far been analysed by the salivary gland method. Among sixteen structural changes, one was a mosaic for two inversions involving separately the *X* and 3*R* chromosomes. Mosaic glands have also been found in the progeny of X-irradiated males[2]; the special features of the present case are: (1) mosaicism for two independent changes and (2) the fact that in any one nucleus both changes were either present or absent. Of thirty-eight nuclei analysed, seventeen contained both inversions, twenty-one neither. Since in the preparation of the slides only one larva was used at a time, a mixture of two sets of glands on the same slide could not occur. The possibility that nuclei in unanalysed parts of the larva may have contained only one of the inversions cannot be ruled out; but the simplest interpretation is that both changes arose simultaneously either immediately after fertilization or through delayed effect at a later mitosis. The first alternative requires that in both *X* and 3*R* only one of the broken sister chromatids formed an inversion, while the other was restituted in the old order, and that at anaphase the two inverted chromatids segregated to the same pole. The second alternative dispenses with these requirements and is therefore rather more probable. It suggests that conditions which affect the nucleus as a whole may result in the simultaneous opening up of latent breaks in several chromosomes.

Another structural change consisted of a reversed repeat involving regions 7 and 8 of the *X*-chromosome. Repeats, whether in reverse or normal order, which occur in the progeny of treated males, must have arisen as chromatid changes. The individuals containing them presumably are mosaics, carrying the duplication in part of their cells and the complementary deficiency in the remainder. With a favourable distribution of the two types of cells, this

kind of mosaicism has indeed been observed after treatment with X-rays[2,3] and mustard gas[4]; in other cases the deficiency may not have been accessible to analysis, or it may not have given rise to viable tissue.

The origin of such a duplication-deficiency in the newly fertilized zygote need not involve a true delayed effect, but only differences in the way in which the broken sister chromatids undergo reunion. X-ray duplications presumably arise by this mechanism. Their frequency in Bauer's experiments[5] was seven duplications out of 688 structural changes; Kaufmann[6] found a similar frequency. After mustard gas treatment of males, Mehtab[7] obtained two reversed repeats among eleven structural changes. Added to the present sample, this gives a frequency of three reversed repeats among twenty-seven changes, a markedly higher value than that found for X-rays. It suggests that some special effect of chemical treatment, probably its after-effect, favours the occurrence of repeats. It should also be noted that reverse repeats cannot arise without previous breakage of the chromosomes; the frequent occurrence of this type of change after mustard gas treatment indicates that at least many of the structural changes induced by mustard gas cannot be explained by non-homologous crossing-over (see ref. 8).

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Inability of Acetylcholine Antagonists to protect Mice against the Toxicity of 'Tensilon'

The anticurare action of 'Tensilon' (3-hydroxy-*N*-dimethylethylanilinium bromide) was considered by Randall[1,2] not to depend upon cholinesterase inhibition. Hobbiger[3] and Hall and Parkes[4] showed, however, that 'Tensilon' does not reverse neuromuscular block after treatment of the preparation with tetraethyl pyrophosphate, implying the necessity of active cholinesterase for the effect.

We have recently described the protection afforded to mice against the toxicity of anticholinesterase drugs by antagonists of acetylcholine[5]. Animals were injected intravenously with atropine, 10 mgm./kgm., tubocurarine, 0·1 mgm./kgm., or hexamethonium, 40 mgm./kgm., and the decrease in intravenous toxicity of simultaneously injected neostigmine or tetraethyl pyrophosphate may be quoted as examples:

	Neostigmine	Tetraethyl pyrophosphate
LD 50 alone	0·306 mgm./kgm.	0·2 mgm./kgm.
LD 50 with atropine	0·66 ,,	0·56 ,,
LD 50 with tubocurarine	4·19 ,,	0·73 ,,
LD 50 with hexamethonium	4·5 ,,	0·666 ,,

Corresponding values obtained with 'Tensilon' have shown, however, that these antagonists provided no protection at all against the toxicity of this substance.

LD 50 of 'Tensilon' alone	18·6 (17·6–19·6) mgm./kgm.
LD 50 with atropine	17·4 (16·35–18·5) ,,
LD 50 with tubocurarine	*c.* 20 mgm./kgm. (2 dose-levels only)
LD 50 with hexamethonium	17·6 (16·45–18·8) mgm./kgm.

These results would certainly seem to be inconsistent with the participation of cholinesterase inhibition or the augmentation of cholinergic function in the toxicity of 'Tensilon'.

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Toxicity of Erythromycin

In the course of experiments using young guinea pigs as test animals, it was found that erythromycin given orally or intraperitoneally caused the animals to look ill after two to three days, with ruffled fur, anorexia, disinclination to move and subnormal temperature, followed by death on the sixth to eighth day with emaciation and signs of diarrhœa. No obvious common cause of death could be found macroscopically or microscopically in sections of liver, spleen, kidney or lung, although occasionally liver necrosis and renal tubular degeneration were seen, accompanied by albuminuria, red cells and casts in the urine and slightly raised blood urea.

It may be seen from Table 1 that, with small numbers of animals, toxicity is independent of age (weight) of the animal or the type of preparation, but is related to the dosage and route of administration, that is, blood and tissue concentration. Guinea pigs weighing 160 gm. were given erythromycin orally or intraperitoneally in doses of 62·5 mgm./kgm. at 12-hr. intervals, and killed 2 hr. after the third dose. The serum and liver concentrations were 2 μgm./ml. and 16 μgm./ml. respectively after injection, and 0·1–0·2 μgm./ml. and 0·9 μgm./ml. orally. A high degree of toxicity is indicated by the lethality of 500–600 μgm./kgm. injected in one dose, where the blood and tissue concentrations must have been extremely low and transient. Guinea pigs injected intraperitoneally with 100 mgm. erythromycin (625 mgm./kgm.) died in 3–6 hr. Doses used as in Table 1 caused death in 3–12 days, averaging $7·1 \pm 0·2$ days for forty-five guinea pigs.

Hamsters of 50–60 gm. weight treated intraperitoneally with 30–200 mgm./kgm. erythromycin in one or more doses also died after approximately thirteen days, with a terminal illness closely resembling that of guinea pigs.

This delayed toxicity has not been recorded in other work on erythromycin, where the oral *LD*50

Table 1. Toxicity of Erythromycin for Guinea Pigs

Preparation	Route of administration	Daily dosage (mgm./kgm.)	Average weight of animals (gm.)	No. of days treatment	No. of animals used	No. of animals dead
Aqueous suspension tablets 'Ilotycin'	Oral	110	180	6	5	4
	,,	65	180	3	5	2
	,,	33	180	3	10	4
	,,	16	180	3	5	0
Aqueous sol. pure crystalline erythromycin	Intraperitoneal	33	180	3	5	5
'Ilotycin heptonate' saline sol.	,,	5·5*	180	1	5	2
		0·5*	180	1	5	2
		6·2*	800	1	5	4
		0·6*	800	1	5	1
,,	Intravenous	5·5*	180	1	1	1
		0·6*	180	1	1	1

* Single dose.

for guinea pigs is reported as 413·4 ± 51·7 mgm./kgm. [1]. It may be recalled that penicillin is toxic for guinea pigs, although there is little positive evidence regarding the nature of this action.

We wish to thank Dr. J. E. French for his assistance in the interpretation of the histological sections.

The erythromycin used as 'Ilotycin' in this work was supplied by Eli Lilly and Co., Ltd., the crystalline erythromycin by Abbott Laboratories, Ltd.

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Potent Diphtheria Toxin within the Cells of *C. diphtheriae*

All the exotoxins except diphtheria toxin have been demonstrated within the bacterial cells in a very early stage of culture. So far as diphtheria toxin is concerned, it has been postulated, but never proved, that the exotoxin is formed within the cell. I have, however, previously deduced the possibility of temporary existence of the toxin within the cell from the morphological and biochemical characteristics of this organism[1,2]. I believe that the failure to show the presence of the toxin was due to the fact that physiologically young cells of *C. diphtheriae*, however early they might be harvested, could not be obtained when static culture was used.

By using shaking cultures, I have obtained physiologically young cells containing the highest toxicities ever found. The shaker rotated at the rate of approximately 130 cycles per min. with an amplitude of 13 cm. Each flask of 200 ml. capacity contained 20 ml. of Pope's medium. A series of flasks was sampled at the three stages of growth: logarithmic phase, that of negative acceleration, and maximum stationary phase. The bacilli harvested from each flask were washed with water, suspended in 0·01 per cent merthiolate solution and then tested for toxicities by subcutaneous or intraperitoneal injection. Toxicities of the bacilli harvested at the three stages, such as, for example, 12, 15 and 35 hr. intervals, are compared in Table 1.

It was found that both the very young and the very old bacilli contained little toxin within the cells,

Table 1

	Incubation time (hr.)	Bacterial growth (mgm. *N*/20 ml.)	*Lf*/ml. (in culture filtrate)	*MLD*/mgm. *N*
No. 1	12	7·7	0	< 25
No. 2	15	11·8	15	>300
No. 3	35	13·9	55*	< 25

* Maximum titre produced in this medium. As the toxin titre in the filtrate already reached to 50 *Lf* at the 24th hour, almost all the toxin produced within the cell is thought to be excreted outside in 24 hr.

Table 2

MLD/gm. (dry weight)	Authors
75	Prigge, R. (ref. 3)
1	Eisler, M. (ref. 4)
21,300*	(in this report)

* Cell suspension of *C. diphtheriae* corresponding to 1 mgm. nitrogen was dried at 60° C., measured for its weight, and proved to be 14 mgm.; *MLD* 300 in Table 1 was multiplied by 1,000/14.

and the toxin content of the bacilli was highest in the period of decelerating rate of multiplication. This result was different from that for other exotoxins, because the bacilli harvested in the logarithmic phase, for example, at the 12th hour (see Table 1), showed remarkably lower toxicity than in the period of decelerating growth-rate. About 200–350 *MLD* per mgm. nitrogen was usually obtained from the bacilli during the period of decreasing growth-rate, but once the value of 750 *MLD* per mgm. nitrogen was obtained.

It is inevitable that the toxin content of the bacilli in this period is variable because toxin production and excretion occur together for such a short time. My titre is compared with the highest toxicities reported by other authors in Table 2. The toxicity I obtained was identified by the findings at adrenal glands of injected guinea pigs and by the neutralization test by diphtheria antitoxin. Thus, this work shows that diphtheria toxin is formed within the cell.

I thank Prof. T. Tani for his encouragement and guidance.

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Growth- and Inhibiting-Substances in Relation to the Rest Period of the Potato Tuber

In an investigation of the growth- and inhibiting-substances in the potato tuber in relation to its rest period, Hemberg[1] has shown that potato peelings contain an acid and a neutral growth-substance in addition to acid and neutral growth-inhibiting-substances. On the basis of molecular weight determinations by diffusion through agar, and sensitivity towards acid and alkali, he concluded that the acid growth-substance is in all likelihood indole-3-acetic acid. In addition, he was able to show that the neutral growth-substance could be converted to the acid growth-substance by enzyme action, and concluded that the former is probably indole-3-acetaldehyde. The disappearance of the acid growth-inhibiting

substance from the potato tuber towards the end of the rest period is considered by Hemberg to be the primary cause of the breaking of dormancy in the potato tuber.

The purpose of the experiments reported here was to determine and possibly to identify the growth- and inhibiting-substances present in the potato tuber by the method of paper chromatography, followed by the *Avena* bioassay as originally described by Luckwill[2] and Bennet-Clark *et al.*[3]. The methods used were as follows. Peelings from potatoes of the variety Kennebec, stored at room temperature in the dark, were extracted at regular intervals from the time the potatoes were lifted up to the time of sprouting eight weeks later. Peelings were cut into small pieces, covered with peroxide-free ether, and placed in a refrigerator at 4° C. for 48 hr. Ether extracts were then separated into neutral and acid fractions according to the method of Larsen[4]. The final ether fractions were concentrated to small volume and applied as spots to the starting line of chromatograms (Whatman No. 1 paper), run for 3½ hr. at 30° C. with *n*-butanol saturated with 2*N* ammonia as solvent. The ascending test-tube method as described by Rockland and Dunn[5] was employed. Bioassay of developed chromatograms was carried out by the *Avena* straight-growth method using a local oat variety, *Avena byzantina* var. Jongensklip, as test material. Developed chromatograms were divided into fifteen 1-cm. segments, each covered with 1 ml. distilled water in small specimen tubes, and ten 3·3-mm. subapical oat coleoptile sections floated on each eluate followed by incubation at 30° C. for 6 hr. The mean elongation of ten coleoptile sections expressed as a percentage of the original length was plotted against the position of the paper segments on the chromatograms as shown by histograms. Results obtained with the acid fractions of five potato peeling extracts taken at consecutive dates from the time the potatoes were lifted up to the time of sprouting are shown in Fig. 1. The results are purely qualitative, but give an indication of the relative growth-activity of the substances present in each extract. Dotted lines indicate the mean percentage elongation of control segments from blank chromatograms run concurrently, a difference of 2·4 per cent (2 × standard error) above or below the control being considered significant. The positions of the synthetic growth-substances indole-3-acetic acid (IAA), indole-3-butyric acid (IBA), indole-3-acetaldehyde (IAc) and indole-3-acetonitrile (IAN) run concurrently on similar chromatograms were marked by guide lines, and could be revealed as coloured spots by spraying chromatograms with Ehrlich's reagent (1 per cent *p*-aminobenzaldehyde in 1*N* hydrochloric acid). The respective R_F values for the above growth-substances were: indole-3-acetic acid, 0·28–0·30; indole-3-acetonitrile, 0·87–1·0; indole-3-butyric acid and indole-3-acetaldehyde, 0·40–0·42.

Based on a comparison of growth activity with that of guide spots of the synthetic compounds, all extracts apparently contain indole-3-acetic acid and a second acid growth-substance which is invariably separated from this region by a definite zone of inactivity on the chromatogram and could therefore not be ascribed to tailing of the indole-3-acetic acid spot. This second growth-substance occupies the same position on the chromatogram as both indole-3-butyric acid and indole-3-acetaldehyde. It is not an aldehyde, as it invariably occurs in the acid fraction of the extract and does not form an addition

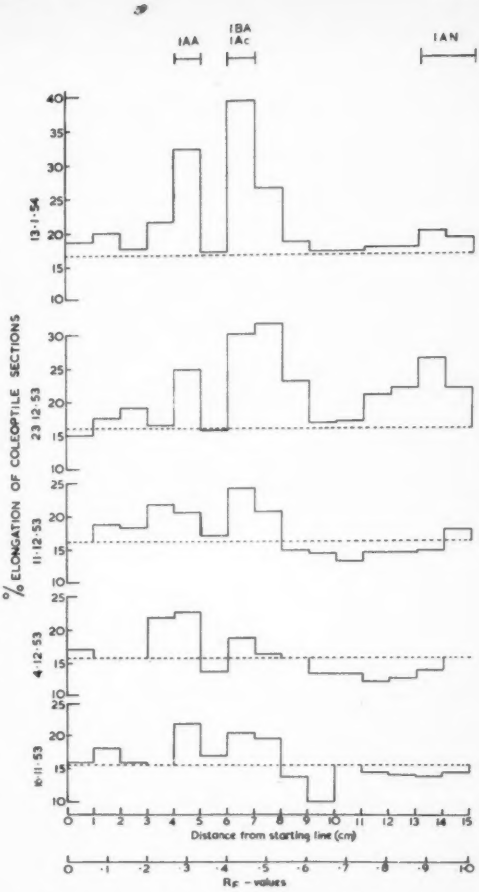

Fig. 1. Histograms showing coleoptile extension-growth in the presence of 1-cm. sections cut from chromatograms of the acid fraction of potato-peeling extracts. Bottom to top: consecutive dates from time potatoes were lifted up to time of sprouting. Dotted lines indicate extension growth of controls. Position of synthetic growth-substances shown by guide lines marked IAA, IAc, IBA and IAN

product with sodium bisulphite. Consequently it is suggested that this second growth-substance could possibly be indole-3-butyric acid. It will be noted that as dormancy is gradually broken, this second growth-substance shows a constant increase in activity relative to that of indole-3-acetic acid, and when sprouting commences its relative activity is even larger than that of the latter.

The presence of an acid inhibitor in the position 8–11 cm. (R_F 0·52–0·74) is strongly evident during the first five weeks, but gradually diminishes up to the time of sprouting, when it has entirely disappeared. However, as will be seen from the histograms, the disappearance of the inhibitor approximately three weeks (23.12.53) before sprouting is apparently associated with the appearance in the extracts of a third growth-substance which is not detectable in the earlier stages of dormancy. This third growth-substance occupies the same position on the chromatogram as synthetic indole-3-acetonitrile, and as the presence of that substance in potato tuber extracts has previously been reported by Bennet-Clark and Kefford[6], it is suggested that it is

the same substance. In all extracts there are indications of a fourth growth-substance with an R_F value of 0·08–0·15. Bennet-Clark and Kefford[6], Lexander[7] and Terpstra[8] have reported a growth-substance which moves more slowly than indole-3-acetic acid with approximately similar R_F values. Recently, Stowe and Thimann[9] have suggested that this growth-substance is probably indole-3-pyruvic acid, which they have identified in maize endosperm. It would appear that here again our fourth growth-substance with low R_F may be indole-3-pyruvic acid.

Neutral fractions of potato peeling extracts assayed at the same time as the above gave indications of one or more inhibitors which do not, however, disappear at the end of the rest period. Except for the presence of the nitrile at the time it appears in the acid fraction, no other growth-substances were evident in the neutral fractions. The presence of the nitrile in both acid and neutral fractions is, according to Bennet-Clark and Kefford[6], due to its being carried over from ether into bicarbonate solution and back to ether on re-acidification during fractionation of the original extract. The neutral growth-substance of potato peelings described by Hemberg[1] may be identical with indole-3-acetonitrile as the latter can, like indole-3-acetaldehyde, be converted to indole-3-acetic acid[10].

From the point of view of dormancy, the above results support the theory of Hemberg[1] that the breaking of dormancy in the potato tuber is primarily due to the disappearance of an acid inhibitor. The simultaneous increased activity of both indole-3-acetic acid and indole-3-butyric acid with the disappearance of the acid inhibitor indicate that the latter may function as an anti-auxin or competitive inhibitor. As the disappearance of the acid inhibitor is associated with the appearance of a growth-substance which may be indole-3-acetonitrile, it is possible that the latter is also in some way connected with breaking of the rest period.

A detailed report of the above investigation will be published elsewhere.

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Varietal Susceptibility of Brassicas to Molybdenum Deficiency

Molybdenum deficiency under Irish conditions has previously been reported to occur in clovers and swede turnips[1]. During the 1953 season, a severe outbreak of whiptail on cauliflowers occurred on a commercial plot at one of the centres mentioned. The soil, which had an initial *p*H of 5·3, had received a dressing of 1½ tons of ground limestone per acre as well as a dressing of superphosphate, muriate of potash and sulphate of ammonia at 5, 2 and 3 cwt. per acre respectively.

Severely affected	Moderately affected to slightly affected	Unaffected
Cauliflower : Cambridge No. 6 Cambridge No. 7 Self-protecting	Cauliflower : Yates Progress Autumn Giant Brussels sprouts : Cambridge No. 3 Cambridge No. 1 Broccoli : Early Feltham	Cauliflower : All-the-Year-Round Brussels sprouts : Masterpiece Cluceed Broccoli : Mid June 1649 May Wonder April Queen Cabbage : Primo Winningstad Rearguard Kale Savoy : Perfection Market Garden January King Sprouting Broccoli : Early Purple

Shortly after the plants were set out, severe symptoms of whiptail appeared on the varieties Cambridge No. 6 and Cambridge No. 7. The variety All-the-Year-Round, which had received identical cultural treatment, was not affected, though it did show some effects of manganese toxicity.

In another plot where a number of varieties of Brassicas were grown, the Cambridge varieties again showed a severe incidence of whiptail, whereas most other varieties of Brassicas were either unaffected or but slightly affected.

Duplicate plots of affected varieties were treated with sodium molybdate at 2 lb. and 4 lb. per acre; this treatment effected a considerable improvement and resulted in head formation where buttoning had not already taken place. The same varieties were sown on a similar soil type in 1954, and again the Cambridge varieties of cauliflower showed a pronounced susceptibility to whiptail, No. 6 being the most severely affected and No. 7 the least affected. Cambridge No. 5, which was sown in 1954 only, was also affected.

The soil in which the condition occurred showed a level of available molybdenum as determined by

Fig. 1

the oxalate method to be in the region of 0·14 p.p.m. [2]. A symptom of the deficiency which does not appear to have been previously recorded is the production of bell-shaped leaves (Fig. 1). These would appear to result from the fusion of the lamina of basal leaves followed by abscission of the growing point. The level of molybdenum at which particular varieties of Brassicas become affected by whiptail is at present under investigation.

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A Remarkable Disintegrative Effect of Skatole upon Certain Rumen Ciliate Protozoa

Hogg and Elliott[1] noted that indole and skatole were both highly toxic towards the aerobic free-living ciliate *Tetrahymena pyriformis*. A concentration of 0·01 per cent of indole, for example, killed all organisms in a vigorous culture in two hours, but these workers made no mention of any characteristic change in appearance of the cells. We have now shown that these substances are highly toxic to the anaerobic ciliates of the sheep's rumen, particularly the holotrichs (*Isotricha* and *Dasytricha*) and also *Ophryoscolex*. These ciliates had been separated from strained rumen contents, washed and maintained alive and active for several hours in a phosphate buffer (without antibiotic) at *p*H 7·2 as described by Heald, Sugden and Oxford[2]. On a molecular basis skatole was much more toxic than indole to the rumen ciliates; but if the comparison was made at concentrations near saturation in the buffer employed, indole being the more soluble compound, the respective effects upon the final appearance of the cells were almost equally spectacular. Briefly, not only did all ciliary motion cease in two hours at 37°, but also a phenomenon resembling a drastic mechanical disintegration took place. The outer pellicles of the holotrichs, and also of *Ophryoscolex*, were torn asunder with liberation of the internal contents of the cells, so that after gently shaking the tube, instead of the rapid re-formation of a layer of ciliates at the bottom below a clear supernatant, there was a dense uniform turbidity throughout due to the release of storage polysaccharide granules and other inclusions from the disrupted cells.

The effect is markedly similar to that due to the anionic detergent 'Teepol', as described by Oxford[3]; but since indole and skatole do not, of course, greatly lower the surface tension of the buffer, another explanation of their action has to be found. Any such explanation must take account of the following facts:

(1) The rapid disruptive effect is only exhibited near the saturation point, that is, *c.* 0·1 per cent for indole, and 0·025 per cent for skatole (*c.* 0·002 *M*) in the buffer employed. This applies also to those isomers of skatole which have so far been tested, namely, 2- and 7-methylindoles. These appear to have similar solubilities to skatole, which, however, acts much more rapidly than either of the others and produces a denser final turbidity.

(2) Isatin, which is also sparingly soluble in the buffer (*c.* 0·12 per cent), acts in a fashion very similar to indole. Aniline, however, is not highly toxic.

(3) More highly polar indole derivatives related to tryptophan, like tryptamine, tryptophanol and indole-3-acetic, -propionic and -butyric acids, are not highly toxic and have no disintegrative effect at *p*H 7 at a concentration of 0·1 per cent.

(4) The toxic effect of indole or skatole cannot be nullified by addition of tryptophan, serine, casein hydrolysate or glucose to the buffer.

It would appear that although a fairly close resemblance to the tryptophan structure, as in skatole, increases the disruptive power of these indole derivatives, the primary requisites for toxicity are physical, namely, slight water- and ready lipoid-solubility, and the absence of any strongly polar centre in the molecule. Since indole—and perhaps skatole—are possible products of bacterial degradation of protein in the rumen, the presence of these and similar compounds may provide an explanation for some of the puzzling variations in density and composition of ciliate population in the normal rumen which undoubtedly occur from time to time.

Our thanks are due to Prof. H. N. Rydon, Department of Industrial Chemistry, College of Technology, Manchester 1, for a gift of a specimen of 7-methylindole.

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Goitre and the Iodine Content of Cow's Milk

During a recent systematic investigation in the Netherlands, it was found that at all seasons marked differences existed between the iodine contents of milk supplied to creameries in goitrous and non-goitrous areas. The location of these areas, in general, corresponds with those found by investigations on thyroid enlargement and thyroid histology in humans and farm animals[1].

In addition to the local differences, a seasonal variation, roughly corresponding inversely to the milk yield, was observed. Therefore, it is essential to make the period of collection of the milk samples as short as possible in order to get strictly comparable results. In the present investigation, some hundreds of samples were collected each time on the same day. The variation of iodine content with time has often been disregarded in previous investigations, and as a result the distinction of goitrous from non-goitrous regions by examination of the milk supply has been needlessly obscured.

In Table 1 a summary of the iodine values, obtained with our method of analysis[2], is recorded.

For a general survey of the iodine status of cattle, the determination of iodine in the milk offers distinct advantages over determination in the blood or histological investigation of thyroid glands. Collection of milk samples is comparatively easy, and the large number of contributing animals living in the same conditions rules out factors of individual variation in quite a simple way.

Table 1

Area	No. of creameries (N)	Mean iodine content of milk : ($\bar{I}$) Summer (in μgm./100 ml.)	Winter (in μgm./100 ml.)
Goitrous	78	0·97 (σ* = 0·026)	2·06 (σ = 0·053)
Transitional	37	1·38 (σ = 0·047)	3·21 (σ = 0·13)
Non-goitrous	43	2·11 (σ = 0·077)	4·88 (σ = 0·15)
Extreme coastal	14	3·43 (σ = 0·21)	8·35 (σ = 0·59)

* $\sigma = \sqrt{\frac{\Sigma(I-\bar{I})^2}{N(N-1)}}$; in which I stands for the actual iodine contents.

I wish to thank Prof. E. Brouwer for suggesting this work, a detailed account of which will be published elsewhere.

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Analysis of Milk in Deficiency Diseases and Intoxications of Cattle

In the diagnosis of deficiency and of poisoning of animals, one generally relies on the chemical analysis of the classical substrates like blood and liver. Eventually the composition of the food is also taken into consideration. It is surprising that in farm animals, and even in lactating animals, general methods largely derived from medical routine are used and that, for example, the milk as a substrate has been neglected.

Nevertheless, in the Netherlands some successful attempts have been made to obtain information by other methods. Thus examination of urine has been shown to offer an insight into the ingestion of potassium, sodium, chlorine and sulphate by cows at pasture or stall-fed[1]. Information about iodine metabolism may be obtained by histological examination of thyroid glands of newborn calves[2]. (In contrast to the situation for other farm animals and humans, it is possible to collect large quantities of thyroid glands because approximately 45 per cent of all newborn calves are slaughtered a few days after birth.)

We believe that more precise information about iodine ingestion can be obtained by the analysis of milk samples. In the preceding communication, the occurrence of marked differences in the iodine content of cow's milk is reported, reflecting the goitre status in cattle.

Because iodine is not the only variable milk constituent, we suggest the chemical analysis of milk as a method in all cases in which a distinct variability in milk composition depending on food intake has been established. This should include the determination of vitamins[3] and trace elements like iodine and copper[4] in deficiency, and of manganese[5], zinc[5], molybdenum[5], arsenic[6], lead[7], insecticides[8] and other toxic substances in excess (a review of the latter is in preparation).

For a quantitative evaluation of the results of the analyses, undoubtedly some fundamental investigations remain to be carried out in connexion with the influence of the milk yield, stage of lactation, etc. In a research programme requiring a preliminary survey of the availability of the above-mentioned compounds in the food of milking cows over a large number of homogeneous districts, much of the individual variation can be ruled out by examining milk samples obtained from creameries in these districts (see preceding communication).

Elements such as molybdenum and manganese, which may be constituents of the metal of milk containers, etc., are not likely[5] to contaminate the milk to the same extent as surface coatings, like zinc, copper and nickel.

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Autonomous Differentiation of some Chick Neurons isolated in Chorion-Allantoic Grafts

The problem of differentiation of neurons consists in identifying the factors, of intrinsic or extrinsic nature, that act upon the neural embryonic cells and the time and modality of their action.

The methods of studying the isolated development of neuroblasts (ectopic transplantation, explantation, destruction of connexions or of peripheral organs, etc.) have been employed with clear results for the Mauthner cells of amphibians[1]. Extending these researches to other types of neurons, I have taken into consideration different neurons of the chick, isolating various fragments of the embryonal neuraxis by means of implants into the allantochorion membrane[2].

The purpose of this brief account is to illustrate results on the recurrent axon neurons of the optic lobes and of the Purkinje cells of the cerebellum of the chick in very small implants.

It has been demonstrated[2] that in isolated fragments consisting of about half the embryonic tectum (at the stage of the primary optic vesicle), after the nineteenth day of incubation the recurrent axon neurons are perfectly well differentiated (Fig. 1,*B*); the presence in these isolated fragments of the recurrent axons is the best proof that the peculiar orientation of these fibres is not determined by antagonistic neurobiotactic fields of physiological activity of any kind (as was supposed by Leghissa, 1946).

In implanted fragments of about one-third or one-fourth part of one-half of the tectum, we observed various degrees of deformation of the tectum cells due to great disturbance by the vessels invading the implant and especially to the abnormal organization of the fragment, which tend to reach a ball-like form. These conditions and the limited growing space are factors that make normal differentiation

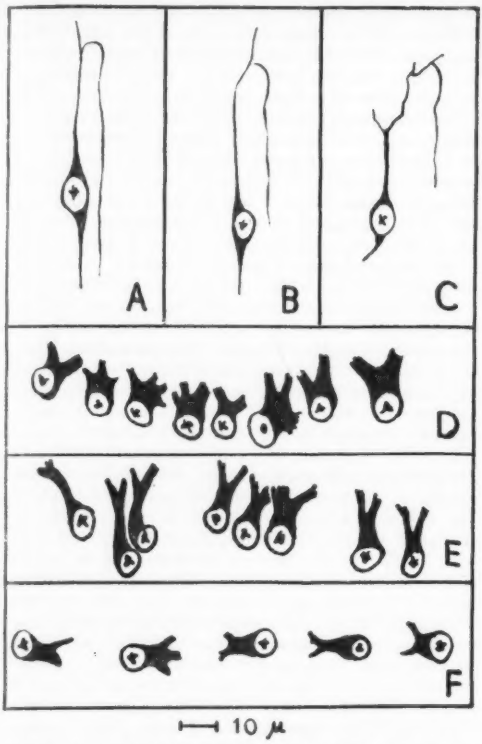

Fig. 1. Camera lucida drawings of some spindle-shaped tectal cells with recurrent axon and of some Purkinje cells of the cerebellum of a normal chick after the nineteenth day of incubation (*A*,*D*), compared with cells of the same age isolated at the primary optic vesicle stage and implanted in the allanto-chorionic membrane; *B*,*E*, from a fragment equal to half the organ (tectum or cerebellum) and *C*,*F*, from a fragment equal to about one-fourth of one-half (see text)

impossible. Nevertheless, even in the smallest bits of tissue these neurons tend to become spindle-shaped, and the axon tends to direct itself in a recurrent way. Very often in these conditions the curve of the axon is wider than the normal, and some collateral branches are present (Fig. 1,*C*).

Similar experiments with cerebellar fragments show Purkinje cells to be very well ordered in a single layer and with the dendritic lobe normally oriented towards the external surface (Fig. 1,*E*). Also, in very small fragments with few Purkinje cells and without any organization of surfaces, the cells are arranged in a single layer and distributed at a regular distance from each other; but the dendritic pole, still clearly evident, is not oriented in a unique direction owing to the absence of a directional organization of the fragment, but is indifferently directed against the neighbouring cell (Fig. 1,*F*).

These experiments lead us to the conclusion that the shape and form of the neurons are intrinsically determined, at the moment of histogenetical determination, and completely independent of any physiological activity. Also the orientation of fibres (for example, the recurrent axons of tectal spindle cells) is to be considered as an intrinsically determined susceptibility of the fibre to react specifically to morphological (not physiological) orientating factors such as the polarity of the fragment and the polarity of the cell itself.

The fundamental importance of physiological factors is shown later by many results, among which hyperplasia is especially evident, when the differentiated cells are physiologically connected.

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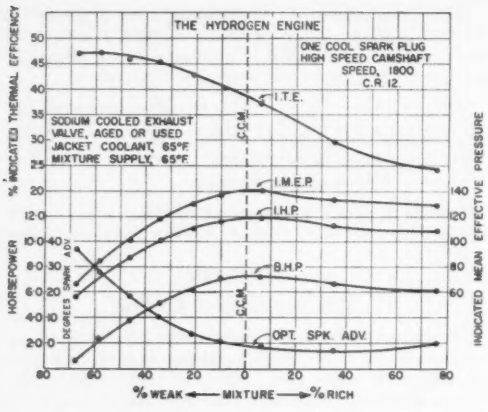
The Hydrogen Engine

It has always been stated by others that it is necessary to use weak mixtures with air when hydrogen is used as a fuel for Otto-cycle engines. Thus Ricardo[1] reported that "if an attempt were made to run with a rich hydrogen–air mixture violent pre-ignition occurred, accompanied by firing back in the carburettor, which rendered further running impossible. Even with the compression ratio lowered to 3·8 : 1, the same thing occurred". Similar effects were obtained later by A. F. Burstall[2] when using a Ricardo *E*.35 engine in the Engineering Laboratory, Cambridge, and still later by Egerton, Smith and Ubbelohde[3], when using an ethyl knock-testing engine for experiments at Oxford.

The igniting effect is generally described as pre-ignition, but by some observers as 'detonation'. Downs, Walsh and Wheeler[4], as a result of experiments with an *E*.6 Ricardo engine, state that "in most cases, owing to the extreme ease with which it ignites, a mixture strength richer than about 25 to 30% weaker than chemically correct cannot be used. If the attempt is made to run with a richer mixture, self-ignition occurs so early on the compression stroke that the mixture is eventually ignited in the induction manifold". Similar igniting effects were obtained by Anzilotti and associates when using a *C.F.R.* engine in a Du Pont Laboratory, Wilmington, U.S.A.

We have found as a result of experiments with a *C.F.R.* engine that premature ignition of hydrogen–air mixtures occurs solely when the exhaust valve or the ceramic core of the spark plug attains an igniting temperature in respect of the mixture, and otherwise only by nuclear ignition due to finely divided carbon produced by the decomposition of lubricating oil. Thus by reducing the temperatures of the spark plug core and the exhaust valve, and avoiding the passage of lubricating oil into the combustion chamber at an excessive rate, it has been possible to run the engine at speeds rising to 1,800 r.p.m., and with a compression ratio as high as 12 : 1. A maximum of 47½ per cent has been obtained for indicated thermal efficiency, and one of 146 lb./sq. in. for indicated mean effective pressure was obtained at 1,500 r.p.m. These values exceed those recorded in the literature of the subject by a wide margin. To obtain still higher values would require an engine designed to avoid leakage of hydrogen past the piston, and a combustion chamber having a reduced surface-to-volume ratio. Typical performance results as obtained with a speed of 1,800 r.p.m. and a compression ratio of 12 : 1 for hydrogen–air mixtures ranging from nearly 80 per cent weak to more than 70 per cent rich are given in Fig. 1.

Our experimental results are not in agreement with the conclusions of Downs, Walsh and Wheeler, that



Engine speed, 1,800 r.p.m.; compression ratio, 12 : 1

self-ignition arising from a chain reaction occurs in an engine.

The experiments were carried out on behalf of the Defence Research Board (Canada), in the Department of Mechanical Engineering, University of Toronto, with the co-operation of Prof. E. A. Allcut, head of the Department, and will be described in detail in a Canadian journal.

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Ultrasonic Absorption in Castor Oil, Carbon Disulphide, Benzene and Xylene

Ultrasonic absorption in some liquids has been measured by the method of heat development. The apparatus and its working was designed in such a way as to make it free from error due to the variation of generator power and also due to reflexion. A 3 Mc./s., 100 W. quartz generator produced the beam in liquid kerosine, contained in a vessel with cork paddings at the ends. In a small double-walled metallic vessel with asbestos packing, having a suitable coat of cement, two mica windows of 0·002 cm. thickness were fitted to allow the beam to pass in and out again after absorption. Two such vessels were made with exactly similar windows and different separations; the separations of windows were 3·6 cm. and 4·6 cm. Arrangements were made to place the front windows in the same relative position with respect to the quartz. The rise in temperature in these fairly non-conducting trap vessels, with different liquids, was measured in the steady condition. The electrical wattage to produce the same steady difference of temperature between the trap vessel and the outer kerosine was determined by a separate experiment. The temperature of the kerosine in the outer vessel was controlled by running ice-cold water around the vessel.

In the experimental arrangement, the energy absorbed in the trap vessel was $I\{1-\exp(-\beta x)\}$, where β, the energy absorption coefficient, was 2α, α being the usual amplitude absorption coefficient. I is the incident intensity in the liquid, and would be the same for all liquids in the trap vessel if we consider that the interface reflexion remains the same in all cases. In cases of very viscous liquids, however, we expect interface reflexion to be large, unlike the case of ordinary organic liquids. In all liquids, however, for the two vessels, I would be the same, and comparative measurements of wattage due to absorption may be made in the two vessels, and hence the value of α/f^2 for the liquid may be estimated. The expected wattage ratios for different values of α/f^2 are shown in Table 1. The experimental mica separations are used for calculations.

The experimental values of the steady temperature differences measured with accurate thermometers and confirmed by several observations, and of the wattages in the two vessels measured by the electrical method, to give the same steady temperature-differences, are given in Table 2.

If we consider that the beam transmitted to xylene, benzene and carbon disulphide through the mica window remains almost the same, the stiffness or viscosity of the liquids being of the same order, and if we consider that α/f^2 in xylene cannot be greater than 75×10^{-17}, the observed experimental value by other methods, we find, by comparison of Tables 1 and 2, α/f^2 for benzene is also not much greater than

Table 1

$\alpha/f^2 \times 10^{17}$	$\beta = 2\alpha$ with $f = 3 \times 10^6$	$\{1-\exp(-\beta x_2)\}$ $x_2 = 4{\cdot}6$ cm.	$\{1-\exp(-\beta x_1)\}$ $x_1 = 3{\cdot}6$ cm.	$\frac{1-\exp(-\beta x_2)}{1-\exp(-\beta x_1)}$
75	0·0135	0·0603	0·0474	1·272
115	0·0207	0·0909	0·0718	1·266
800	0·144	0·4844	0·4046	1·197
5,000	0·90	0·9841	0·9609	1·024

Table 2

Liquid	Temp. diff. large trap and outer vessel	Temp. diff. small trap and outer vessel	Wattage in large trap $I\{1-\exp(-\beta x_2)\}$	Wattage in small trap $I\{1-\exp(-\beta x_1)\}$	$\frac{I\{1-\exp(-\beta x_2)\}}{I\{1-\exp(-\beta x_1)\}}$
Xylene	3·0° C.	3·6° C.	2·0	1·6	1·25
Benzene	3·7° C.	—	2·1	—	1·25*
Carbon disulphide	4·2° C.	4·8° C.	3·2	2·5	1·28
Castor oil	7·0° C.	11·2° C.	2·6	2·5	1·04

* Determined with a different set of observations under changed conditions.

75×10^{-17} and that of carbon disulphide not much greater than 115×10^{-17}. This gives the incident wattage on the mica windows as about 32 W. The ratio of wattages in the two vessels agree, within the experimental error of 2 per cent, with the expected values of the ratios for these values of α/f^2. If in the case of carbon disulphide the real α/f^2 was as high as $5{,}000 \times 10^{-17}$, the ratios of wattages in the two vessels would have been 1·024 and the temperature rise in the smaller vessel, from the wattage–temperature graph, would have been 6·3° C. instead of 4·8° C. This is certainly much beyond the probable error of 0·1° C. in measured values of temperature differences. That with a value of α/f^2 of $5{,}000 \times 10^{-17}$ the ratio of wattages in the two vessels should have been 1·024 is beautifully confirmed by experiments on castor oil, where the ratio of wattages in the two vessels agrees with the expected value, within the range of experimental error. The smaller wattages recorded for castor oil are evidently due to a large reflexion from the interface. The experimental results show that the mean absorption coefficients of carbon disulphide and benzene are not much beyond the values for other liquids of the same nature.

The explanation for this discrepancy between the observed mean absorption coefficient and the absorption coefficient determined by other methods may be understood on the basis of variability of velocities and absorption coefficients in the same liquids, as suggested by one of us[1]. This variability would cause the components of a wave pulse to be more and more out of step with distance. No other explanation of this discrepancy in results seems to be feasible.

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A New Development in Aids for Sub-normal Vision

The optical aids conventionally used for the improvement of sub-normal vision at near viewing distances (for example, reading) comprise compound, short microscopic systems of varying magnifications, often obtained by placing an additional convex lens over the objective of a Galilean telescopic unit. These microscopic spectacles present a number of disadvantages; thus they have a very restricted field of view (usually less than 30°), they cause changes in spatial perception and, moreover, are heavy, conspicuous, and, in Australia, very costly. Compound systems are employed because of the contention, expressed throughout the literature, that single high-power convex lenses could not provide the necessary field properties.

I have recently succeeded in developing a series of single high-power convex lenses which, with respect to objects placed in their focal planes, are adequately corrected for oblique astigmatism, curvature error, and distortion over a wide field of view (60°–75°).

These lenses can thus be used as simple microscopic spectacle lenses for the improvement of sub-normal vision. They have already given excellent clinical results in a considerable number of cases, which have been reported elsewhere (*Aust. J. Optometry*, July 1954). All the experimental lenses were made by C. J. Tenukest in the Precision Optics Workshop of the School of Applied Physics of the New South Wales University of Technology[1].

Principles of lens design. With spectacle lenses generally, chromatic aberration, spherical aberration and coma are negligible, the latter two because of the small aperture stop formed by the pupil of the eye. The problem is the study of the images formed by the lens on the far-point-sphere of the eye, by pencils passing through a fixed aperture stop effectively located at the eye's centre of rotation (as the eye moves behind the stationary lens). For lenses assumed 'thin', and moderate obliquities (less than 30°), Emsley and Swaine[1] have developed the necessary third-order theory for ordinary 'best-form' spectacle lenses. By combining four of their equations we obtain for the sagittal and tangential image vergencies:

$$L'_s = L + F + \frac{y^2F}{n(n-1)^2}\left[\frac{2n+1}{2}F_2^2 + F_2\left\{(n^2-1)S - \frac{n}{2}(n+2)F\right\} + \frac{n^2}{2}F^2 - n(n-1)FS + \frac{(n-1)^2}{2}S^2\right] \quad (1)$$

$$L'_T = L + F + \frac{y^2F}{n(n-1)^2}\left[\frac{4n+5}{2}F_2^2 + F_2\left\{3(n^2-1)S - \frac{(n+2)^2}{2}F\right\} + \frac{n}{2}(n+2)F^2 - (n-1)(n+2)FS + \frac{(2n+1)(n-1)^2}{2}S^2 + 2F_2L(n^2-1) - n(n^2-1)FL + 2(n-1)(n^2-1)SL\right], \quad (2)$$

where L is object distance (in dioptres), F is total power of lens, F_2 is back surface power of lens, S is distance from lens to eye's centre of rotation (in dioptres), n is refractive index and y is effective lens aperture (obliquity).

For freedom from oblique astigmatism,

$$L'_T - L'_s = 0. \quad (3)$$

For freedom from curvature error,

$$\frac{1}{2}(L'_T + L'_s) = L + F. \quad (4)$$

By making appropriate substitutions, putting the expression inside the brackets equal to zero, and solving for F_2, a series of ellipses are obtained which give the conditions for the 'correction' of either aberration in terms of lens form (F_2) over a range of lens powers (F). Outside the range of the ellipse, the lens form which reduces the aberration to a minimum is found by differentiating the equation expressing the amount of aberration present with respect to F_2.

Emsley[2] has also recently elaborated the third-order theory for 'spectacle distortion' (based on the 'angle condition' instead of the usual 'tangent condition'), for which he gives the following equation:

$$u_1 = u'_2\left(1 - \frac{F}{S}\right) - u'^3_2\frac{F}{6S}\left[\frac{(n^3-1)}{n^2(n-1)^3S^2}\left\{(3F^2_2 + F_2(6(n-1)S - 3nF) + n^2F^2 - 3n(n-1)FS + 3(n-1)^2S^2\right\} - 1\right] \quad (5)$$

For spectacle distortion to be corrected, the quantity in the brackets has to be equated to zero and the equation solved for F_2; again an ellipse is obtained. With respect to the rotating eye, S denotes the dioptric distance from the lens to the eye's centre of rotation, and for the stationary eye the distance from the lens to the eye's pupil.

For a lens used as a simple microscope (magnifying lens) and placed in the spectacle plane, we now have to solve equations (3), (4) and (5) for positive values of F by putting $n = 1{\cdot}5$, $S = 37{\cdot}5$ ($s = 27$ mm.) and $L = -F$.

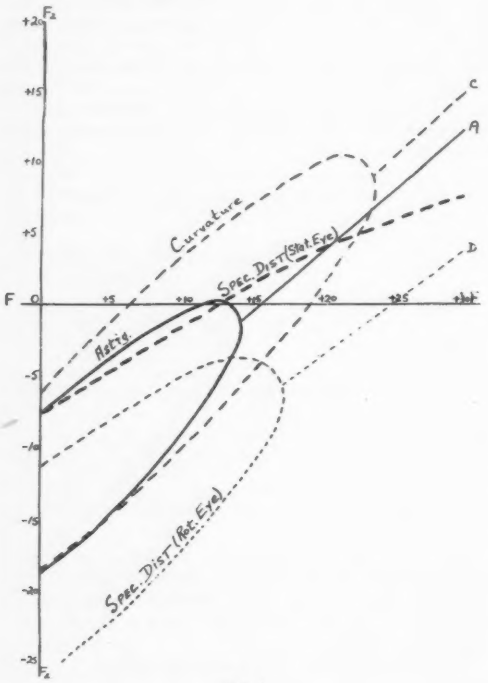

Fig. 1

The semi-ellipses showing the conditions for freedom from each aberration, together with the straight lines giving the conditions of minimum aberration outside the range of the ellipses, are shown in Fig. 1. They are given by the following equations, derived as explained above.

Oblique astigmatism:

$$F_2 = \frac{1}{7}(6F - 93{\cdot}75 \pm \sqrt{1{,}422 + 56F - 11{\cdot}2F^2} = \frac{48F - 750}{56}.$$

Curvature of field:

$$F_2 = \frac{1}{7{\cdot}5}(6{\cdot}87F - 93{\cdot}75 \pm \sqrt{2{,}186 + 118F - 9F^2}) = \frac{55F - 750}{60}.$$

Spectacle distortion (rotating eye):

$$F_2 = \frac{1}{48}(36F - 900 \pm \sqrt{127{,}800 - 432F^2}) = \frac{3}{4}F - \frac{900}{48}.$$

Spectacle distortion (stationary eye):

$$F_2 = \frac{1}{8}(6F - 240 \pm \sqrt{30{,}704 - 18F^2}).$$

Inspection of the graph shows that in several regions the curves intersect or approach each other closely. (Calculation shows that in the region of the curves a change in F_2 of one dioptre will cause oblique astigmatism or curvature error to the extent of approximately $F/50$.)

It is therefore possible to design a series of single high-power convex lenses which, with respect to objects in their focal plane, are adequately corrected for oblique astigmatism, curvature error and spectacle distortion over a considerable field of view, and recognition of this forms the principle of design of the lenses referred to above.

The same principle of intersecting and approaching correction-ellipses can also be successfully applied to the design of 'best-form' spectacle lenses for objects located from infinity ($L = 0$) to a distance of 25 cm. from the eyes ($L = -4$), over a wide range of lens-powers. It is hoped to publish a further communication on this subject at a later date. Finally, consideration is being given at present to the design, along similar lines, of an achromatic doublet eyepiece suitable for various types of optical instruments.

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A New Iron Boro-carbide

DURING a current investigation of the phase relations in the iron–carbon–boron system, X-ray diffraction has revealed the existence of a new boro-carbide which appears to have the structure of the complex cubic carbide reported by Westgren[1] in the chromium–carbon system. He showed that the idealized unit cell contains 92 Cr atoms and 24 C atoms, thus corresponding to the composition $Cr_{23}C_6$; moreover, about 25 per cent of the chromium may be replaced by iron in this carbide. Westgren also reported carbides of similar structure in the iron–molybdenum–carbon and iron–tungsten–carbon systems, in particular in high-speed steels; these carbides, which have been designated 'kappa' by Goldschmidt[2], correspond, at least approximately, to the compositions $Fe_{21}Mo_2C_6$ and $Fe_{21}W_2C_6$. Comparison of the diffraction data for the present boro-carbide with that for the complex cubic chromium carbide as described by Goldschmidt[2] is presented in Table 1. The lattice parameter of the boro-carbide is found to be $10{\cdot}62 \pm 0{\cdot}02$ A.

Specimens were prepared from mixtures of powders (ground to pass a 100-mesh sieve) of an iron–carbon alloy (4·4 per cent carbon) and an iron–boron alloy (5·7 or 8·9 per cent boron) or boron by heating in an evacuated 'Vycor' tube at 850° C. for extended periods. Although various changes in the diffraction patterns were noted during the first few days, further changes were not observed in specimens heated for periods in excess of a week.

Table 1. INTERPLANAR SPACINGS OF CARBIDES

hkl	Boro-carbide* d (A.)	Intensity	$Cr_{23}C_6$† d (A.)	Intensity
311	3·187	W		
222	3·055	W		
400	2·644	W		
420	2·367	S	2·380	MS
422	2·161	S	2·172	M
333, 511	2·037	VS	2·048	S
440	1·872	S	1·882	M
531	1·792	S	1·800	M
600, 442	1·765	M		
620	1·674	VW	1·683	W
533	1·613	W		
622	1·595	MW	1·605	MW
640	1·466	VW		
800	1·325	W		
644, 820	1·284	W	1·291	M
660, 882	1·248	M	1·255	MS
555, 751	1·222	M	1·229	M
840	1·183	W		
753, 911	1·162	W	1·168	M
931	1·111	W		
844	1·082	M	1·086	S
933	1·065	MW	1·070	MW
1,040	0·9830	W	0·9883	M
1,042	0·9668	W	0·9716	M
775	0·9549	W	0·9597	W
880			0·9408	W
971	0·9254	M	0·9300	S

* Present data, from X-ray diffractometer, cobalt radiation.
† Goldschmidt (ref. 3); interplanar spacings converted to angstroms.
Key to intensities: VS = very strong; S = strong; MS = medium to strong; M = medium; MW = medium to weak; W = weak; VW = very weak.

This new boro-carbide has been found in several of the samples in the range $1\frac{1}{2}$–$2\frac{1}{2}$ per cent boron and $2\frac{1}{2}$–$4\frac{1}{2}$ per cent carbon. Analogy with the Westgren carbides would suggest a composition corresponding to $Fe_{23}(C,B)_6$. The question as to whether this boro-carbide can exist over a substantial range of compositions is not settled; however, all samples so far observed have the same lattice parameter within the stated error of $\pm$ 0·02 A.

If we choose to consider the hypothetical carbide $Fe_{23}C_6$, then it may be said that Westgren and Goldschmidt have produced carbides in which chromium, molybdenum or tungsten has been substituted for iron. To the best of our knowledge the present boro-carbide is the first reported case in which another element (boron) has been substituted for carbon in this structure. This type of carbide has generally been found in, and regarded as characteristic of, some stainless and high-speed steels. It is possible that the appearance of boron therein may eventually shed some light upon the pronounced influence of boron upon the hardening properties of steel.

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Effect of Nitrogen Dioxide on the Thermal Decomposition of Ethyl Nitrite

THE value of gas chromatography as a technique for the analysis of the minute quantities of products formed during the kinetic studies of gas reactions is well illustrated by recent work on the gas-phase reaction between ethyl nitrite and nitrogen dioxide. Studies of the behaviour of ethyl nitrite, ethyl nitrate and water on a partition column of kieselguhr wetted with di-butyl-phthalate and eluted with nitrogen revealed that a complete separation of a mixture of the esters and water can be achieved. Using gas chromatography, it has thus been possible to identify three major components, namely, ethyl nitrite, ethyl nitrate, and water, in the residue from the reaction between ethyl nitrite and nitrogen dioxide at about 190° C. Few other micro-analytical techniques would have enabled this to be done so simply or so quickly.

40 mm. of ethyl nitrite and 40 mm. of nitrogen dioxide were allowed to react in a glass vessel of approximately 90 ml. capacity. The temperature of the reaction was about 190° C. Analysis of the residues from interrupted runs for periods up to one hour are given in the table. These show that the quantity of ethyl nitrate produced reaches a maximum after 10 min. and becomes negligible after one hour. The residue of ethyl nitrite was identified on all chromatograms but not quantitatively estimated.

Time of reaction (min.)	2·0	2·8	3·5	5·5	7·5	11·0	15·0	25·0	45·0	60·0
Pressure of ethyl nitrate (mm. mercury)	1·8	2·5	3·9	4·4	5·1	5·3	4·6	3·4	0·9	$\simeq$0·0

The formation of ethyl nitrate during the decomposition of ethyl nitrite in the presence of nitrogen dioxide affords direct evidence in favour of the reaction:

$$C_2H_5O + NO_2 \rightarrow C_2H_5O.NO_2, \quad (1)$$

originally suggested by Phillips[1] in explanation of the inhibition of the thermal decomposition of ethyl nitrate by nitrogen dioxide. In this event, it is possible that previous values obtained for the rate of decomposition of ethyl nitrate do not refer to the rate of the reaction:

$$C_2H_5O.NO_2 \rightarrow C_2H_5O + NO_2, \quad (2)$$

since the decomposition involves the equilibrium

$$C_2H_5O.NO_2 \rightleftharpoons C_2H_5O + NO_2. \quad (3)$$

These conclusions would mean that the effect of nitric oxide on the decomposition of ethyl nitrate previously ascribed[2] to the reaction:

$$C_2H_5O.NO_2 + NO \rightarrow C_2H_5O.NO + NO_2, \quad (4)$$

is probably due to the occurrence of

$$C_2H_5O + NO \rightarrow C_2H_5O.NO, \quad (5)$$

proceeding in preference to (1) in the presence of initially added nitric oxide. This would also explain Levy's[3] observation of the production of ethyl nitrite (in quantities greater than 70 mol. per cent) during the normal decomposition of ethyl nitrate.

Acknowledgment is made to Dr. Peter Gray (Cambridge) for recent correspondence on this subject.

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Structural Changes during the Fatigue of Copper

Recent experiments on annealed low-oxygen high-conductivity copper have shown that, under direct fatigue stresses, the structural changes revealed by back-reflexion X-ray photographs (cobalt $K\alpha$ radiation ; film-to-specimen distance, 10 cm.) are markedly dependent upon mean cyclical load.

The tests were carried out on a variable-frequency testing machine, which applied alternate tensile and compressive loads to the test specimen. The mean cyclical loads were conveniently varied within restricted limits by placing weights on a counter-balance pan which was attached to the straining device of the machine by a flexible steel cable passing over a pulley.

At frequencies of both 200 c./min. and 400 c./min., small variations in the value of the counterweight attached to the straining device were found to produce disproportionate changes in the X-ray diffraction patterns of test-specimens after 1,000 stress cycles at about $\pm$ 5 tons/sq. in. At the same time, permanent dimensional changes were similarly influenced by variations in the magnitude of the counterweight, as will be seen from Table 1.

Table 1. Permanent Strains after 1,000 Cycles at $\pm$ 5 tons/sq. in Approximately

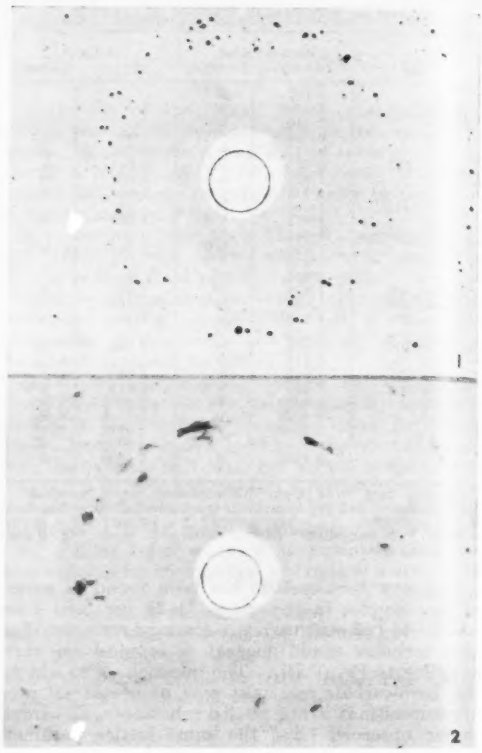
200 c./min. tests		400 c./min. tests	
Counterweight (lb.)	Permanent strain (per cent)	Counterweight (lb.)	Permanent strain (per cent)
40	− 1	40	− 1
60	− 0·3	80	Nil
80	+ 1	120	+ 1·5

In those cases where the permanent dimensional changes were slight or negligible, the X-ray patterns showed relatively small changes except for a general diffusion of the sharp diffraction spots typical of the annealed material (see Fig. 1). However, the changes in the patterns were quite pronounced in all cases where the permanent dimensional changes exceeded about $\pm$ 1 per cent, at both high and low frequencies (see Fig. 2).

Wood and Head[2], in their direct reversed-stress tests on oxygen-free high-conductivity copper, attributed their observations of pronounced diffusion and circumferential arcing of X-ray diffraction spots at 'sub-critical' testing frequencies ($<$ 350 c./min. approximately) and the relative absence of changes at higher frequencies to the influence of a delay period, representing the finite time between application of a stress and development of the corresponding plastic strain. These tests were done on the machine used in the present work.

However, repeated tension experiments which I have carried out on similar material have shown that the use of the higher testing frequencies fails to inhibit structural changes (as revealed by X-ray diffraction) and dimensional changes, at least after 100 cycles.

Other work[3] has shown that, even under static loading conditions, annealed copper can withstand reversed stresses of $\pm$ 5 tons/sq. in. with only slight changes in X-ray diffraction patterns, providing a suitable 'stepped' loading sequence is followed. It is clear that, in this latter case, structural changes are minimized by the choice of an appropriate preliminary loading schedule rather than by any time-delay mechanism.



Diffraction patterns: (1) specimen which showed zero extension after 1,000 stress cycles at 400 c./min.; (2) specimen which suffered 1·5 per cent elongation after 1,000 stress cycles at 400 c./min.

The marked dependence of structural and dimensional changes upon mean cyclical load in direct-stress tests can result in an erroneous impression being obtained of the nature and extent of fundamental structural changes under fatigue stresses, unless load-balancing operations of high precision are practised. In the absence of confirmatory evidence from low- and high-frequency tests carried out in other types of machines (for example, rotating bending tests), it seems possible that the critical-frequency effect reported by Wood and Head[2] may have been attributable primarily to progressive dimensional changes arising from characteristics of the testing machine.

Some preliminary rotating bending tests have, in fact, been carried out, and X-ray diffraction studies have indicated that the structural changes, even at 21 c./min., may be relatively slight.

Acknowledgment is made to the Chief Scientist, Department of Supply, for permission to publish this communication.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 22

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. Maldwyn Jones: "Plastics for the Radio Engineer".

UNIVERSITY OF EDINBURGH (in the Natural Philosophy Department, Drummond Street, Edinburgh), at 7.30 p.m.—Mr. W. Lawrence: "The Experimental Synthesis of Speech".

Monday, November 22—Tuesday, November 23

INSTITUTION OF GAS ENGINEERS (at Church House, Westminster, London, S.W.1), at 9.30 a.m. daily—20th Autumn Research Meeting.

Tuesday, November 23

INSTITUTE OF PHYSICS, NON-DESTRUCTIVE TESTING GROUP (in the Lecture Theatre of the New Horticultural Hall, Vincent Square, London, S.W.1), at 2 p.m.—Mr. R. Halmshaw and Sr. G. Spiegler: "The Fundamentals of Radiographic Definition, Resolution and Unsharpness".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. H. E. M. Barlow: "The Application of the Hall Effect in a Semi-Conductor to the Measurement of Power in an Electromagnetic Field"; Dr. A. H. M. Arnold: "Audio-Frequency Power Measurements by Dynamometer Wattmeters".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. Hermann Bondi: "Science as an Education".*

ILLUMINATING ENGINEERING SOCIETY (at the Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. C. H. Edlin: "Light and Crime Detection".

Wednesday, November 24

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. H. Weil-Malherbe: "Blood Adrenaline in Relation to Mental Activity".*

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Bicentenary Competition—"Life in 2000 A.D.". Reading of first two prizewinning essays—Wing Commander T. R. Cave-Browne-Cave: "A Scheme for Rooftop Roadways"; Mr. C. E. H. Watson: "A System of Underground Roadways for London".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. S. Hazzledine Warren: "The Clacton Channel Deposits"; Dr. K. A. Joysey: "The Geological Distribution of Carboniferous Blastoids in the Craven Area".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. M. J. Goddard: "The Development and Design of Direct-Coupled Oscilloscopes for Industry and Research".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. E. Mitchell Learmonth: "Some Aspects of Soya as a Bread Improver"; Dr. Betty C. Hobbs: "The Problem of Synthetic Cream".

Thursday, November 25

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. J. P. Stevenson: "Insects and Disease".*

EAST MALLING RESEARCH STATION (at the Laboratories, East Malling, near Maidstone, Kent), at 3 p.m.—Prof. T. A. Bennet-Clark, F.R.S.: "Water and Plant Growth" (Amos Memorial Lecture).

TEXTILE INSTITUTE (at 10 Blackfriars Street, Manchester 3), at 3 p.m.—Prof. S. C. Harland, F.R.S.: "Recent Progress in the Breeding of Cotton for Quality".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting. Prof. H. Davenport: "Simultaneous Diophantine Approximation".

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. W. Cronin and Mr. J. F. Lang: "Peat-fired Power Stations".*

INSTITUTE OF REFRIGERATION (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Miss M. V. Griffiths: "The Use of Heat Pumps of Small Capacity for Various Purposes in Great Britain".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. N. Thompson: "The Development and Investigation of Fatigue Cracks".

Thursday, November 25—Friday, November 26

INSTITUTE OF METALS (at 4 Grosvenor Gardens, London, S.W.1), at 2.30 p.m. on Thursday, and 10.30 a.m. on Friday—General Meeting for the Discussion of Papers.

Friday, November 26

INSTITUTE OF METAL FINISHING (in the Fitzwilliam Room, Grand Hotel, Sheffield), at 3.45 p.m.—Third Annual General Meeting.

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion—"Geophysical Aspects of Solar Flares". Chairman: Prof. V. C. A. Ferraro. Speakers: Dr. M. A. Ellison, Mr. H. Elliott, Dr. J. S. Hey, Mr. H. W. Newton and Mr. K. Weekes.

PHYSICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Prof. P. M. S. Blackett, F.R.S.: Seventh (1954) Rutherford Lecture.*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. R. D. Lawrence: "Sugar Diabetes, Its Nature and Its Importance".

Saturday, November 27

BOTANICAL SOCIETY OF THE BRITISH ISLES (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, South Kensington, London, S.W.7), at 2.30 p.m.—Annual Exhibition Meeting.

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Sir Richard Winstedt: "Malay Folk-Song".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT EXPERIMENTAL OFFICER to work in the DEPARTMENT OF ENTOMOLOGY on Aphid Ecology—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting 104 (November 25).

SENIOR TECHNICIAN to take charge of the workshop IN THE DEPARTMENT OF PHYSICS—The Registrar, University College of North Wales, Bangor (November 29).

DEMONSTRATOR or LECTURER IN PATHOLOGY—The Registrar, The University, Leeds 2 (November 30).

LECTURER (with an honours degree in engineering and some professional experience) IN MECHANICAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (November 30).

SENIOR LECTURER, LECTURER and ASSISTANT LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, The University, Manchester 13 (November 30).

ASSISTANT AGRICULTURAL ECONOMIST (graduate in economics and/or agriculture)—The Registrar, The University, Bristol 8 (December 1).

TECHNICIAN or RADIOGRAPHER (preferably with qualifications in science, mathematics or radiography) required for therapeutic and tracer measurements with radioactive isotopes—The Secretary, Board of Governors, Hammersmith Hospital and Postgraduate Medical School, Du Cane Road, London, W.12 (December 1).

ASSISTANT LECTURERS (2) IN BOTANY—The Registrar, The University, Manchester 13 (December 4).

HEAD (with a good honours degree, teaching and industrial experience, and preferably with research experience) OF THE ENGINEERING DEPARTMENT—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames (December 4).

PHYSIOLOGISTS, PHARMACOLOGISTS or ZOOLOGISTS (with a first- or second-class honours degree, or equivalent qualification) at a Ministry of Supply Experimental Establishment, near Salisbury, Wilts—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G386/54A (December 4).

UNIVERSITY DEMONSTRATOR IN PHYSICAL CHEMISTRY—Dr. F. B. Kipping, Chemical Laboratory, University of Cambridge, Cambridge (December 4).

SCIENTIFIC OFFICER (British nationality, with an honours degree in chemistry and postgraduate experience in agricultural chemistry, or an honours degree in agricultural chemistry) IN THE CHEMICAL RESEARCH DIVISION of the Ministry of Agriculture, Government of Northern Ireland—The Secretary, Civil Service Commission, Stormont, Belfast (December 6).

CHAIR OF GLASS TECHNOLOGY—The Registrar, The University, Sheffield 10 (December 11).

MATHEMATICIANS or PHYSICISTS (with a first- or second-class honours degree in mathematics or physics and preferably with experience of analysis of statistics and preparation of appreciations of trials data) at a Ministry of Supply Experimental Research Establishment, near Salisbury, Wilts, for operational research—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London S.W.1, quoting A.316/54A (December 11).

SENIOR SCIENTIFIC OFFICERS (with a first- or second-class honours degree or equivalent in physics or electrical engineering, and at least three years postgraduate research experience), at the Royal Aircraft Establishment, Farnborough, Hants, to work on research in and development of radio and other fusing techniques for guided weapons and bombs—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.320/54A (December 11).

ASSISTANT KEEPER (with a first- or second-class honours degree in electrical engineering or equivalent qualifications, and preferably a knowledge of at least one modern foreign language) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING AND COMMUNICATIONS, Science Museum (Ministry of Education)—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.270/54 (December 14).

CHAIR OF CHEMISTRY tenable at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 14).

CURATOR (with an honours degree in zoology) OF THE AQUARIUM—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1 (December 15).

LECTURER or SENIOR LECTURER (adequately qualified in chemistry with specialization in the field of physical chemistry) IN PHYSICAL CHEMISTRY, at the University of Tasmania and Hobart Technical College—The Agent-General for Tasmania, 457 Strand, London,

W.C.2, or the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (December 21).

Assistant Director (well grounded in high polymer and physical chemistry, and able to appreciate the impact of fundamental work in these and allied fields on the practical development of plastics, particularly from indigenous resources) of the Division of Plastics and High Polymers—The Secretary, Council of Scientific and Industrial Research, Old Mill Road, New Delhi, India (December 31).

Biometrician for duties which include the design of experiments in all phases of tobacco production, together with the analysis of data and related statistical practice—The Director, Tobacco Research Board of Southern Rhodesia, P.O. Box 1909, Salisbury, Southern Rhodesia (December 31).

Lecturer in Fluid Mechanics in the Department of Aeronautics and Fluid Mechanics—The Secretary of University Court, The University, Glasgow (January 8).

Lecturer in Theoretical Physics—The Registrar, The University, Reading (January 17).

Assistant Lecturer in Applied Mathematics—The Registrar, The University, Nottingham.

Bacteriologist for work primarily concerned with the production and testing of bacterial vaccines and toxins—Head of the Biological Division, The Wellcome Research Laboratories, Beckenham, Kent.

Grassland Agronomist, a Grass Breeder, and a Cereal Breeder (with a good honours degree in botany or agricultural botany), and Assistants to a Cytologist and Grass Breeder (with a pass degree in botany or agricultural botany), at the Welsh Plant Breeding Station, Aberystwyth—The Registrar, University College of Wales, Aberystwyth.

Physicist (with an appropriate science degree and preferably with a knowledge of electronics), to assist in problems related to the treatment of cancer—The Medical Superintendent, Western General Hospital, Edinburgh 4.

Physicists (4) (with a good honours degree and some research experience) to undertake research on (*a*) shrinkage and dimensional stability of fabrics (Ref. P.1), (*b*) creasing and crease-recovery of fabrics (Ref. P.2), (*c*) the fatigue of textile fibres (Ref. P.3), and (*d*) fibre assemblies (Ref. P.4)—The Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester.

Radio Chemist, Principal Scientific Officer or Senior Scientific Officer grade (with a first- or second-class honours degree in chemistry, and at least three years postgraduate research experience), to work in a team engaged on fundamental research work on radioactive materials —Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 154/WGE/2.

Research Assistant (honours graduate, preferably with research experience) in Organic Chemistry—The Secretary, University College, Exeter.

Senior Scientific Officer or Scientific Officer (with a first- or second-class honours degree in physics) to carry out research into the measurement of radiation with emphasis on the high intensity and high-energy regions—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 81/WGE/2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Building Research Station Digest No. 69 (August 1954): Avoiding Defects in Internal Plastering. Pp. 6. (London: H.M. Stationery Office, 1954.) 3*d*. net. [19

Department of Scientific and Industrial Research. Road Research Laboratory. Road Research Technical Paper No. 31: The Durability of Road Tar (With Special Reference to Its Use in Tar-macadam Wearing Surfaces). Pp. vi+48+4 plates. (London: H.M. Stationery Office, 1954.) 2*s*. 6*d*. net. [29

The Year Book of the International Council of Scientific Unions, 1954. Pp. ii+82. (London: International Council of Scientific Unions, c/o The Royal Society, 1954.) 5*s*. [29

Recommendations on Library Co-operation. Pp. 8. (London: National Central Library and National Committee on Regional Library Co-operation, 1954.) [29

National Central Library. 38th Annual Report of the Executive Committee for the year ending 28 February 1954. Pp. 22. (London: National Central Library, 1954.) [29

London and Home Counties Regional Advisory Council for Higher Technological Education. Applied Research in Technical Colleges. Pp. 44. (Publication No. 18.) (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1954.) 2*s*. 6*d*. [239

National Physical Laboratory. Notes on Applied Science No. 5: Gauge Making and Measuring. Pp. v+79+1 plate. (London: H.M. Stationery Office, 1954.) 3*s*. net. [249

Journal of Nuclear Energy. Vol. 1, No. 1 (August), 1954. Pp. iv+92+iv (2 plates). Published quarterly. Annual subscription 90*s*. Single issues 25*s*. (London: Pergamon Press, Limited, 1954.) [249

Medical Research Council of Ireland. Annual Report for the year ended December 31, 1953. Pp. 34. (Dublin: Medical Research Council of Ireland, 1954.) [249

Communications and Electronics. Vol. 1, No. 1 (October), 1954. Pp. 120. A monthly journal. Annual subscription 30*s*. Single issues 2*s*. 6*d*. (London: Heywood and Co., Ltd., 1954.) [249

Department of Scientific and Industrial Research and Fire Offices' Committee. Joint Fire Research Organization. Reference to Scientific Literature on Fire—Part 6, 1952. By Miss E. M. Shakeshaft, Miss B. F. W. Baxter and Miss I. G. Wolanska. (Library Bibliography No. 5/Part 6). Pp. 63. (Boreham Wood, Herts.: Fire Research Station, 1954.) [249

British Welding Research Association. Welding Research for Industry. Pp. 24. (London: British Welding Research Association, 1954.) [249

Department of Scientific and Industrial Research. Memoirs of the Geological Survey of Great Britain—England and Wales. Geology of the Country around Chatham. (One-Inch Geological Sheet 272, New Series.) By H. G. Dines, S. C. A. Holmes and J. A. Robbie. With contributions by Dr. S. Buchan and F. H. Edmunds. Palæontology by R. V. Melville. Pp. viii+157+5 plates. (London: H.M. Stationery Office, 1954.) 21*s*. net. [249

Scottish Plant Breeding Station. Annual Report (Abridged). Pp. 70. (Edinburgh: Scottish Plant Breeding Station, 1954.) [249

Annual Report and Transactions of the Yorkshire Philosophical Society for the year 1953. Pp. 15. (York: Yorkshire Philosophical Society, 1954.) [249

Friends of the Lake District. Report and News Letter, August 1954. Pp. 16. (Ulverston: Friends of the Lake District, 1954.) [249

Other Countries

Histochemische Methoden. Lieferung 3. Pp. 24. (München: R. Olderbourg, 1954.) 6 D. marks.

Southern Rhodesia. Geological Survey Bulletin. No. 40: The Geology of the Lower Sabi Coalfield. By Dr. W. H. Swift, W. C. White, J. W. Wiles and B. G. Worst. Pp. 115. (Salisbury: Government Printer, 1954.) 15*s*. [249

Annual Report of the Rubber Research Institute of Malaya, 1952. Pp. 115. (Kuala Lumpur: Rubber Research Institute of Malaya, 1954.) [249

Organisation for European Economic Co-operation. Corrosion Problems and Prevention in the Chemical and Petro-Chemical Industries in the U.S.A. (Technical Assistance Mission No. 130.) Pp. 130. (Paris: Organisation for European Economic Co-operation, 1954.) 8*s*. 6*d*.; 1.50 dollars; 420 French francs. [249

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 111, No. 9: On Bolosaurs and the Origin and Classification of Reptiles. By D. M. S. Watson. Pp. 279–450+1 plate. Vol. 111, No. 10: Distribution of the Foraminifera in the Northeastern Gulf of Mexico. By Frances L. Parker. Pp. 451–588+13 plates. Vol. 112, No. 1: The Ant Genus Strumigenys Fred. Smith in the Ethiopian and Malagasy Regions. By William L. Brown, Jr. Pp. 34. Title Page and Index to Vol. 111. Pp. 4. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1954.) [249

Museum of Comparative Zoology at Harvard College. Breviora. No. 34 (July 20, 1954): A Review of the Coxalis, Group of the Ant Genus Stictoponera Mayr. By William L. Brown, Jr. Pp. 10. No. 35 (July 28, 1954): New or Redescribed Pelomedusid Skulls from the Tertiary of Africa and Asia (Testudines, Pelomedusidae). 1: *Dacquemys paleomorpha*, new genus, new species from the Lower Oligocene of the Fayum, Egypt. By Ernest Williams. Pp. 8+1 plate. No. 36 (August 6, 1954): Present Knowledge of the Snake *Elachistodon Westermanni* Reinhardt. By Carl Gans and Ernest E. Williams. Pp. 17. No. 37 (August 18, 1954): On the Evolution of an Oriental Earthworm Species, *Pheretima Anomala* Michaelsen 1907. By G. E. Gates. Pp. 8. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1954.) [249

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 33, No. 4: Philippine Zoological Expedition 1946–1947. Systematics and Zoogeography of Philippine Amphibia. By Robert F. Inger. Pp. ii+183–532. (Publication No. 732.) (Chicago: Chicago Natural History Museum, 1954.) 6 dollars. [249

United States Department of Agriculture. Leaflet No. 363: The Southern Cornstalk Borer. Pp. 6. 5 cents. Leaflet No. 367: The Tomato Fruitworm: How to Control It. Pp. 6. 5 cents. [249

Sveriges Geologiska Indersökning. Ser. A. Kartblad i skalan 1: 50000 med beskrivningar. No. 195: Beskrivning till Kartbladet Särö. Av P. H. Lundegårdh och R. Sandegren. Pp. 106. 10 kronor (med karta). No. 196: Beskrivning till Kartbladet Västeras. Av P. H. Lundegårdh och G. Lundqvist. Pp. 75. 10 kronor (med karta). Ser. C. Avhandlingar och uppsatser. No. 522: Pre-Cambrian Geology of the Pajala District, Northern Sweden. By Tryggve Eriksson. Pp. 38+3 plates. 4 kronor. No. 533: De Geologiska Resultaten Fran Borrningarna vid Höliviken. Del 6: Charophyta from the Middle Trias of the Boring, Höliviken 2. Preliminary Account. By Henning Horn af Rantzien. Pp. 16+1 plate. 1.50 kronor. No. 534: Vätögraniten. Av P. H. Lundegårdh. Pp. 24. 2 kronor. Årsberättelse för År 1951. (Tillhör Årsbok 45 (1951).) Pp. 9. (Stockholm: Kungl. Boktryckeriet P. A. Nordstedt and Söner, 1952–1954.) [249

Museum of Applied Arts and Sciences, Sydney. Annual Report of the Trustees for the year ended 31st December 1953. Pp. 14. (Sydney: Museum of Applied Arts and Sciences, 1954.) [249

Prospects for Atomic Power. By Sir James Chadwick, F.R.S. (Lecture delivered in the McLennan Laboratory, under the auspices of the School of Graduate Studies, University of Toronto, October 15, 1953.) Pp. 12. (Toronto: University of Toronto Press; London: Oxford University Press, 1954.) 6*s*. net. [249

Research Bulletin of the Panjab University. No. 44 (Zoology): Gametogenesis and Fertilization in *Isoparorchis Eurytremun*. By O. Parkash Dhingra. Pp. 21–37+5 plates. 3 rupees, 8 annas. No. 45 (Zoology): Studies on Insect Spermatogenesis. No. 2: Lepidoptera. On the formation of the Acrosome and Mitochondrial Nebenkern in *Prodenia litura* Fabr. and *Anaphaeis* sp. By Sukhdev Raj Bawa. Pp. 39–47+3 plates. 2 rupees, 4 annas. No. 46 (Zoology): Fish Spermatogenesis, with particular reference to the fate of the Cytoplasmic Inclusion. 2: Spermatogenesis of Elasmobranchs (Pleurotremata). By Hem Saga Vasisht. Pp. 49–58+5 plates. 2 rupees, 14 annas. No. 47 (Chemistry): Chloramine-B as a Volumetric Reagent. Part 3: Determination of Metals. By Apar Singh. Pp. 59–62. No. 48 (Chemistry): Chemical Examination of the Oil from the Seeds of *Cassia Absus* Linn. By I. Sen Gupta, Kulwant Singh and Ram Parkash Sood. Pp. 63–69. 1 rupee, 1 anna. (Hishiarpur: Panjab University, 1954.) [249

Pubblicazioni della Pontificia Academia Scientiarum, Citta del Vaticano. Commentationes. Anno 16, Vol. 16, No. 2: Analisi Elettroacustica della Voce Cantata. Da Fr. A. Gemelli, G. Sacerdote e G. Bellussi. Pp. 21–44+9 plates. (Citta del Vaticano: Pontificia Academia Scientiarum, 1954.) [249